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AN ANALYSIS OF RANGE PROBLEMS
IN THE SOUTHWEST

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MANAGEMENT
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AN ANALYSIS OF RANGE PROBLEMS IN THE SOUTHWEST

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FOREWORD

In an area as vast as the Southwestern United States there are several methods whereby the region may be subdivided in order to make a problem analysis of the range situation. One method, popular with agricultural economists, is to divide the region into subareas on the basis of characteristic types of farming and ranching. Another system, and one which is commonly employed by plant geographers, is to base the divisions upon a consideration of physiographic provinces. A breakdown such as this would have some advantages since, in many instances, it would coincide with work center areas. The watershed management specialist would no doubt follow an analysis method wherein the region would be broken up into major drainage basins. The ecologist's approach would consist largely in dividing the region on the basis of vegetational communities or plant formations. The method adapted and used in this analysis follows rather closely that of the plant ecologist inasmuch as a thorough knowledge of ecology is necessary to an adequate understanding of most range problems. Furthermore, management and improvement practices are closely determined by vegetation, climate, and soil. However, certain features of the other methods of analysis have been adopted and coordinated whenever it has seemed advisable.

It is absolutely essential to gain some definite understanding of past range conditions, and of factors responsible for their deterioration,before any adequate, sound plans can be projected which aim at present or future range improvements. This fact should be self-evident, but unfortunately is only too often overlooked. In discussing range problems it is also necessary to include accounts of past research. Failure to present this background material would result in a decidedly unscientific approach to any attempt to outline research problems for future consideration.

AN ANALYSIS OF RANGE PROBLEMS IN THE SOUTHWEST

INTRODUCTION

The Southwest is a land rich in legend and history. The mythical account of the fabulous seven cities of Cibola led to the early exploration of the region by Coronado in 1540. Horses, cattle, sheep, and swine accompanied Coronado's army. These were the first domestic livestock to be brought into this part of the new world. Coronado sought gold and found little but scenery. He dimly appreciated the vast natural resources. Since the time of earliest exploration and settlement (San Juan, New Mexico, 1598), many changes have gradually been wrought within the region. These changes have been greatly accelerated during the past half century. Tremendous irrigation projects, extensive areas of farming, hydroelectric power, timber, copper, coal, oil, and gas production have been developed at great labor and expense. Paved highways and railroads cut across the terrain in all directions. People have come by the hundreds of thousands either to make their living from the land or simply to be able to live in the healthful climate.

The least apparent change over the years and probably the most important,because of its marked influence on the future economy of the region, is concerned with the vegetation of the range lands. Domestic livestock have blanketed the bulk of the land. Too heavy grazing use, continued year after year, has caused marked deterioration and unraveled the protective plant cover, exposing the soil to accelerated erosion. Grasslands that were once extensive are now covered with noxious weeds and half-shrubs such as bitterweed and snakeweed. Other millions of acres of formerly open grassland have now been invaded with low-value juniper and mesquite with subsequent lowering in grazing, watershed and wildlife values. About the only thing that has not changed has been the climate--it is still dry. Water is precious and its scarcity will limit future population growth and development of the agricultural resources. The problem of conserving water and making the most effective use of it is basically important to the welfare of every person in the region as well as to the irrigation farmer and range livestockman. Similarly, the problem of improving and maintaining range land productivity necessitates a general appreciation of other values such as watersheds, timber, and wildlife wherever these are important.

The purpose of this problem analysis is to portray the facts, statistical and otherwise, as they pertain to grazing lands and the range livestock industry in the Southwest (Arizona, New Mexico, and Western Texas) and to briefly discuss the problems relating to the grazing use of these lands. The analysis is also intended to present briefly the past, present, and future range research required to aid livestockmen and range administrators in meeting increasing problems, particularly those relating to grazing management. Such an analysis is both timely and essential for an effective attack on our range research problems. It is timely from the standpoint of the Southwestern Station because within the next two years present cooperative agreements on two experimental ranges will expire (Jornada, transfer of agreement in 1948; Santa Rita, 1949). It is essential because, since 1915, range research work has largely been centered in the semidesert grassland and desert shrub types as they occur on these two experimental ranges. There has also been some work on ponderosa pine ranges as represented within and near the Fort Valley Experimental Forest in Arizona. But there has not been a real, over all analysis of the regional problem. It has not been determined where and how well the results from these experimental ranges fit into the general picture.

In the light of some 30 years or more of range research at the Jornada and Santa Rita, it is evident that such an analysis is long overdue.

GENERAL ASPECTS OF RANGE LANDS IN THE SOUTHWEST

The Southwest is a land of contrasts--many contrasts in land, climate, and people. From an agricultural viewpoint some of the land, for example, the painted desert of northern Arizona, is little more than scenery, while other parts of the region possess excellent grazing lands, and still others are known as the most highly productive farming regions of the West. The climate permits the yearlong grazing of livestock on the greater portion of the range. The population includes descendants of the original Indian inhabitants, the early Spanish, and the historically recent Anglo-Americans.

Ever since the earliest days of the industry, the raising of livestock has generally been a large scale enterprise. There are several reasons for this. In this semiarid region "live" water is scarce. The pioneer recognized early that the most effective way to control land was to own the water. By strategic selection of homesteads and State leases he could evade the limitations imposed by public land laws. The original Spanish and Mexican land grants often comprised solid blocks of extensive range. Then too, in the cattle industry, a relatively large acreage is required to support a cow yearlong. For example, a moderate-sized ranching unit of 200 breeding cows will require from 5,000 to 50,000 acres. In the sheep industry an additional factor enters the picture--predatory animals; because of this the herder system is required which is not economic for bands of less than 1,000 sheep.

The Southwest is considered, for the purpose of this study, as being comprised of Arizona, New Mexico, and the portions of Texas and Oklahoma (Panhandle) west of the 100th Meridian.

In order to clearly visualize and secure a better understanding of the nature and magnitude of range problems in the Southwest it is necessary to sketch at least briefly the scope of the region involved, the history of range use, the economic importance of the range livestock industry, the over all climate, the vegetation and soils.

Extent and Character of Ownership

The Southwest is an inland empire of vast extent with the bulk of its 233 million acres in range. This area is 32 percent of the total range area (728 million acres) of the 17 western states. The bulk of the land is used for grazing on a yearlong basis, but extensive areas are used seasonally. The latter regions include many so-called desert areas in Arizona which are grazed intermittently in the winter and spring by range livestock. In especially favorable years of growth these ordinarily dry ranges produce considerable amounts of forage. Also included in the seasonal ranges (mostly Arizona and New Mexico forests) are lands where grazing use is limited by climate to the summer period of 3 to 5 months. The principal areas excluded are those that are barren or inaccessible. These non-grazing sections include lands enclosed within National Parks, and irrigated and other areas closed to range livestock. On this basis range lands in the region comprise about 91 percent or about 213 million acres of the total land area—made up as follows:

Arizona	61,660,000 acres
New Mexico	74,000,000 acres
Texas and Oklahoma(Panhandle)	77,520,000 acres

The land status of the region is presented in table 1. Arizona is characterized by the predominance of publicly controlled land, where about 77 percent is either owned or subject to publicly administered regulation with 65 percent under Federal jurisdiction and 12 percent State lands. In New Mexico 41 percent of the lands are federally controlled, 16 percent are State owned, and 42 percent private. In Texas and the Oklahoma panhandle

Table 1. Land status in the Southwest (approximate).

	Arizona		New Mexico		Texas and Oklahoma	Total
	Area in acres (000)	Percent	Area in acres (000)	Percent	Area in acres (000)	Area in acres (000)
Federal Land						
National Forests	11,465	16	8,768	11		
Indian Lands	19,248	26	8,578	19		
National Parks & Monuments	2,611	4	324			
Federal Range	9,101	12	14,720	11		
GLO Lands & Game Ref.	4,768	7				
Other Federal	178					
Total Federal	47,371	65	32,390	41		75,761
State Land	8,356	12	12,700	16		
Private Land					81,600	156,939
Railroad	3,771	5	33,200	42		
Other	13,193	18				
Total private	16,964	23	33,200	42	81,600	
Total land area	72,691	100	78,402	99	81,600	232,700

there are no federally owned range lands of consequence. Thus in passing from east to west the status of the lands changes from private ownership to an ever increasing degree of governmental jurisdiction.

In Arizona and New Mexico some of the land is blocked out so that one governmental agency has complete control of large, individual areas. For example, the Navajo Indian Reservation, which covers one-sixth the land area of Arizona is administered by the Indian Service. Many of the National Forests under the administration of the Forest Service are fairly well blocked out but some contain sections of patented and State lands. These generally small holdings are not usually a serious obstacle in range management with the exception of certain localities on the Santa Fé and Carson National Forests in New Mexico. In this part of the region an acute problem exists because there are too many people, with too little productive land, who are dependent upon a limited amount of federally controlled range. In addition to this problem there are extensive areas where the heterogeneity of the ownership pattern is pronounced. For example, in Arizona the Santa Fé railroad holds title to some 3 million acres located on alternate sections and forming a checkerboard pattern. The State lands include sections 2, 16, 32, and 36, unless they were appropriated prior to the laws setting them aside or have been involved in land exchange. Although much has been accomplished by the various agencies in land exchange, there still remains much to be done in blocking out areas to the mutual satisfaction of everyone concerned.

Because of the preponderance of public owned or controlled lands, together with the extensive acreage required for an economical ranching enterprise, it is not unusual for a ranch operator to require, in addition to his private holdings, State leases, a National Forest permit, and a Grazing Service permit. Many of these areas of conflicting administration are gradually being ironed out. The Pearce Act, for example, enables the Grazing Service to consolidate their administration by leasing State, county, or private lands. On the other hand, there are numerous ranches located entirely on patented land, which have been blocked out from some original Spanish or Mexican land grant. In the case of Indian lands, the grazing privilege is held by the Indians who graze the range with the advice and guidance of the Indian Service. Permits for the grazing privilege on National forests are issued largely on the basis of ownership or control of adjacent lands, the proper use of which is dependent on national forest range lands. Permit to use lands administered by the Bureau of Land Management of the Interior Department are issued on somewhat the same basis. Grazing privileges to State lands are obtained by lease through the State Land Commissioner.

Regardless of the land status, responsibility for its proper management and improvement as range rests squarely with the private individual and the public agency involved. The future welfare of the Southwest is dependent on how well and in what manner the range resource is used. To make certain that these lands are used properly and thus conserved is a matter of public concern.

HISTORY OF GRAZING USE

Period prior to introduction of domestic livestock.—Prior to the advent of domestic livestock in the Southwest, the only grazing animals were game--principally deer, elk, antelope, and the great herds of bison on the "staked plains" of eastern New Mexico and western Texas. Historical accounts are numerous but on the whole deal largely in generalizations and often apparent exaggerations as to game numbers and forage production. It is generally recognized that game was plentiful--deer and elk were found on the open grasslands as well as in the forest. Game populations were larger than present-day numbers and at least in the case of bison may have been excessive. In this respect the report of Nicollet ( ) made in 1841 on a bison herd near Ft. Pierre, South Dakota, is of interest even though it refers to the northern portion of the Great Plains:

> "We could discern herds of buffaloes as far as the eye could reach. The green plains regain their uniformity, bounded only by the horizon, and presenting a smooth surface, without one sprig of grass higher than another. The deep furrows made by the buffaloes in their migrating excursions from north to south, and south to north, are the only irregularities of the surface."

Heavy trampling and close grazing of the bison were in part ameliorated by the rotational character of grazing use. From present-day knowledge of grazing habits it would seem logical that the presence of deer and antelope would if anything favor grass vegetation since they are largely browse and weed eaters. On the other hand, elk and bison are quite comparable in forage consumption to cattle--preferring grass. On the whole, however, larger game animals were probably in fair balance with the vegetation because of disease and natural predator checks, although at times there were undoubtedly localized areas where grazing use was too heavy. In such instances starvation no doubt served to bring about natural adjustment of numbers to the forage supply.

References to range conditions prior to the establishment of the livestock industry are meager. Few attempts to draw this information together have been made. One of these attempts was made by Wilcox ( ) in 1911, who compiled the opinions and statements of a large number of explorers and investigators with reference to grazing conditions in the West during the past century. These writings, including Wilcox's discussion of them, are highly contradictory. Part of the reason for this was the inclusion of accounts from observers interested mainly in locating land that could be tilled and who were prone to overlook its value for range. For example, the explorer Pike is cited with reference to New Mexico and "says that aside from the valleys, 'all the rest of the country presents to the eye a barren waste of poor land, scarcely to be improved by culture.'" However, Wilcox's remarks on changes in range conditions, particularly as they pertain to the Southwest are of interest in spite of his contradictions:

> "To one who is familiar with the present range conditions of the arid west as a whole, or any particular section of it, these statements must indicate a striking similarity in the appearance of the range in former times and at present.----general conditions and appearance of the range country have changed but little since the time when they were first explored by white men.-----We may take Arizona and New Mexico as representing the Southwest.---- The feed on the range in Arizona has evidently undergone certain changes in character during the past 20 years, as evidenced by the statements of stockmen--and others; nevertheless the total number of stock has not diminished in recent years to an extent which would indicate an alarming destruction of the range----. M. A. Otero states that in New Mexico 'the range is not being destroyed. The actual area used for grazing purposes supports the same number of head of stock now as in days past.'-----It is evident, however, from the investigations of Griffiths that the range in many parts of Arizona is becoming less and less productive, on account of overstocking and the consequent prevention of reseeding, which leads in turn to excessive erosion of the soil. These factors have brought about exceedingly discouraging conditions in some parts of the territory."

Wilcox's conclusion regarding the Great Plains was that this area "is essentially the same as that described by the early travelers.--- The immense numbers of buffalo in early days and later of cattle have not been sufficient to produce any marked change in the character or amount of range forage upon this area." Wilcox's conclusion is highly erroneous, at least as it applys to the portions of the Great Plains in the Southwest, where millions of acres have been invaded by mesquite, sandsage, snakeweed, and bitterweed, with accompanying reductions in grazing values and increases in soil movement rates.

An account of the vegetation on the Great Plains written over 400 years ago by Castenada, historian of the Coronado Expedition, is significant even if it is somewhat discounted for the evident attempt to impress the reader:

> "Who would believe that 1,000 horses and 500 of our cows and more than 5,000 rams and ewes and more than 1,500 friendly Indians and servants in traveling over these plains would leave no more trace where they had passed than if nothing had been there--nothing...."

Although Coronado's Expedition was one of exploration and not settlement, the year 1540 is important since it marks the entrance of the first domestic livestock into what is now the United States.

Period of Livestock introduction - "Paso por Aqui".--The first extended introduction of livestock in the Southwest was probably made by Onate in 1598 with the settlement of San Juan in northern New Mexico. Nearly a century elapsed before permanent introduction took place because, as Brayer (3) reports: With .....

> "The Pueblo revolt of 1680 most of the cattle (and sheep) in New Mexico were slaughtered, stolen by the Indians, or driven Southward by those settlers lucky enough to escape from the territory. It was not long, however, before the province was reconquered by Don Diego de Vargas who re-introduced beef cattle to New Mexico in 1694. In his plan for the reconquest, this intrepid captain

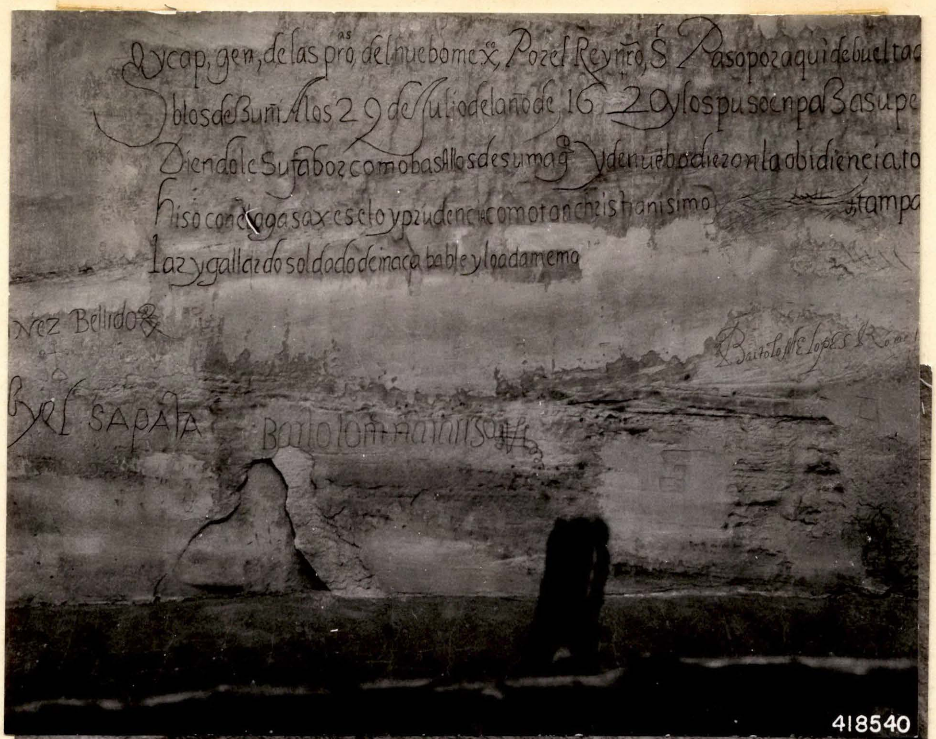
petitioned the Crown of Spain to supply 12 head of cattle for each of the 500 families he intended to take with him to resettle the province. From the records we learn that he was unable to obtain the 6,000 head of cattle desired, but one official document reports that he purchased in northern Mexico 1,070 head of cattle at four and one-half pesos per head--a total of 4,715 pesos (approximately $2,200). The de Vargas reconquest met with quick success, and in the years immediately following, the number of Spaniard settlers gradually increased and the number of beef cattle slowly multiplied, although it was almost 100 years before there was sufficient stock in the province to avert the constant threat of famine.

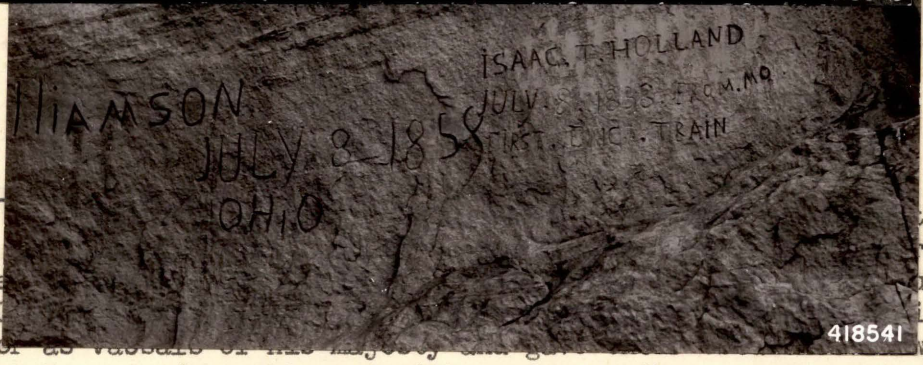
Throughout the Spanish period, which lasted until the establishment of Mexican independence in 1821, meat cattle were a vital part of the pastoral life centering in the Rio Grande Valley. Cattle were used as a medium of exchange, and became one of the most important items of the dowry as well as tangible assets in estates. The several score missions founded by the padres among the Pueblo Indians regularly listed in their inventories, the number of cattle and their annual increase. It was during this era that the wandering Apaches, Navajos and Ute tribesmen, as well as the Comanches on the east began their incursions against the New Mexico ranchos. While the first concern of the marauding Indians was to obtain horses, large numbers of cattle were also stolen. Repeated expeditions were sent out against the Indians but it was not until some years after the American occupation that the tribesmen were quelled and stock depredations ceased.

With the opening of the Santa Fe Trail and the independence of Mexico in 1821, the cattle trade took on new significance. "Yankee" traders were quick to note the importance of cattle in the New Mexico economy and the ease with which these animals were raised. The commercially minded Americans judged the wealth of the New Mexico hidalgos by the number of cattle they possessed, and while sheep were of greater numerical importance than cattle, it was the latter animal which attracted their attention."

Zebulon Pike, on visiting El Paso in 1807, noted that he "put up at the house of Don Francisco Garcia, who was a merchant and a planter. He possessed in the vicinity of the town 20,000 sheep and 1,000 cows."

The raising of livestock in the 18th and early 19th centuries in New Mexico (as elsewhere in the Southwest) was confined largely to areas within a few miles of permanent settlements located on live water such as the Rio Grande. The grazing of the upland and mesa ranges was probably largely confined to incidental use along the trails and by domestic animals gone wild.

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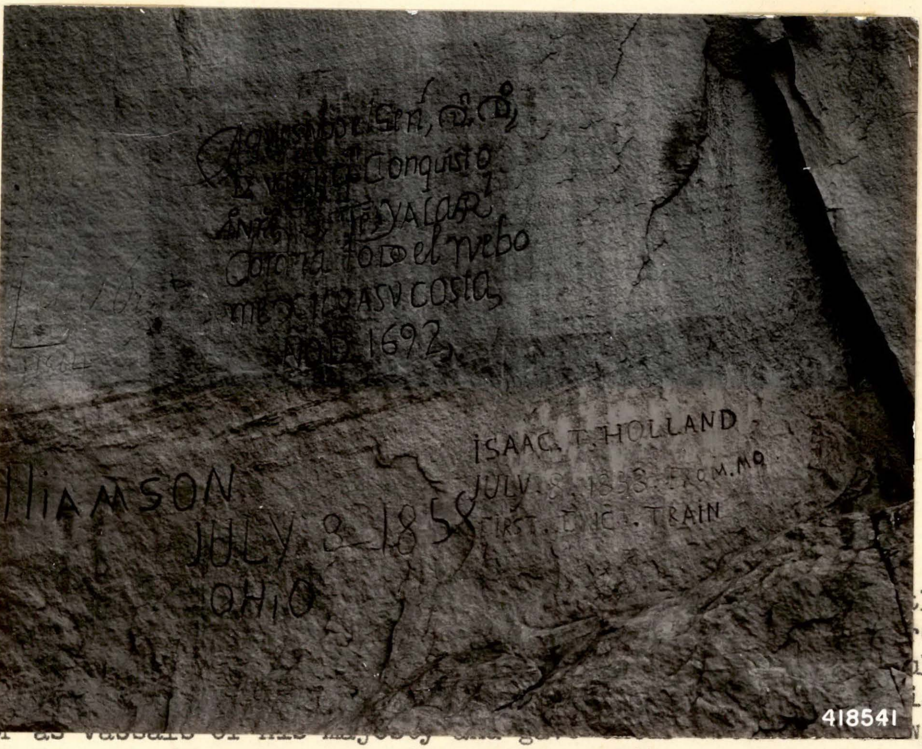
New Mexico, Inscription Rock. "Here was (the) General de Vargas who conquered for our holy father and for the royal crown all of New Mexico at his (own) expense in the year 1692."

First Emmigrant train, July 8, 1858.

Figure 1.--These early inscriptions in Northern New Mexico testify to the early introduction of livestock into the Southwest. Coronado's expedition in 1540 depended on horses for transportation and cattle and sheep for food and barter with the Indians.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New Mexico, Inscription Rock. "The illustrious gentleman and captain general of the provinces of New Mexico passed through here and back from the pueblos of the Zunis by the 29th of July 1620 and placed them in peace at their supplication asking his favor as vassals of his majesty and gave their obedience anew, all which he made favorably and with prudence like a good particular Christian that he is and gallant soldier of everlasting and praiseworthy remembrance."

Bottom photo--

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Figure 1.--These early inscriptions in Northern New Mexico testify to the early introduction of livestock into the Southwest. Coronado's expedition in 1540 depended on horses for transportation and cattle and sheep for food and barter with the Indians.

The first domestic livestock in what is now Arizona were also undoubtedly brought in with the founding of the early Spanish missions. The Jesuit mission of Quebabi near present day Nogales, was established about 1687 near Calabasas in Santa Cruz County. A few years later and 10 miles farther north, on the Santa Cruz river, the Franciscan mission of Tumacacori was established. In the diary of the founder Father Kino, written in 1700, concerning the rounding up of livestock from the missions near Tucson, he states: "We gathered up after branding time and sent alive to California, about seven hundred beeves, one thousand sheep and goats and some horses." Due largely to Indian depredations these early missions did not flourish.

It was not until the period 1825-63 that numerous Mexican land grants were established and livestock were raised in what is now Santa Cruz county. However, Indian trouble, principally with the Apaches, caused the abandonment of many of these early-day ranches and the cattle went wild. The observations of Cooke (   ) made in 1846 along the San Pedro in southern Arizona are of more than passing interest:

> "Next day the march was fifteen miles down the river. It seemed to be a fertile valley, the low ground about a mile wide; salmon trout eighteen inches long were caught. The wild cattle were still more numerous.

A few years later, 1851, Graham reported, "A great many fish were taken in the Babocomari (a tributary of the San Pedro) today. From their appearance I should say there are several quite new species among them."

A hundred years later both these streams are intermittently dry washes with muddy waters whenever they become alive. In order, however, to maintain an unbiased view of the extent to which changes may have occurred since white settlement, it would be well to examine briefly the comments of Ives (   ) made in 1858 in northern Arizona.

> "Under the Southwest base of the San Francisco Peak we camped at a spring (Larue), known to be permanent. There is abundant grazing."

One day later in traveling eastward, Ives remarks:

> "The grass and the scoriae go together and after being rid of the latter the former also became scarcer. We made the first camp after leaving the forest, with plenty of water, but with little pasturage."

Two days later Ives states:

> "The wide valley of Flax river (Little Colorado) could be recognized a long way off by the line of cottonwoods that skirt the banks of the stream. The river is smaller than the Colorado....the same swift, current, chocolate colored water....The bottomlands are in places several miles wide. Here and there are to be found patches of a coarse grass (probably alkali sacaton) which at this season is green and nutritious."

From the few references cited we must conclude that there has been change (mostly deterioration) in the vegetation and streamflow conditions since white settlement. How much, where and specifically what kind of change, remains as yet to be adequately delineated. There yet remains the tremendous task of closely analyzing the wealth of manuscripts in the archives of Spain and Mexico from the viewpoint of the ecologist. Some of this material may prove to be exceptionally valuable in revealing a better picture of the vegetation, streamflow characteristics, and general soil conditions as they existed several hundred years ago. In this respect Ewing's ( ) reference to histories and historians of the Southwest would make a good beginning. For example, Ewing cites briefly the work of Father Ignatz Pfefferkorn ("Beschreibung der Landschaft Sonora" - 2 vols. Cologne 1794-1795) in which flora, fauna, Indians, mining and history are treated in great detail.

Period of Rapid Development and Settlement.--1865-1900.---In this period the first event of significance to the livestock industry was the construction of the transcontinental railroads--because it offered the first accessible market to the east for western range livestock. During the Civil War (1861-1865) over 3.5 million head of cattle had accumulated—mostly in Texas. The famous Texas trail drives to the Kansas railheads began with the start of work on the Union Pacific Railroad in 1866. By these trail drives over 10 million head of cattle were marketed by 1885. The construction of the Union Pacific also spelled the end of the bison on the Great Plains. The railroad divided the bison into two main herds. It made hunting easy and the demand for hides at the same time was so great that slaughter of these animals was inevitable. By 1883 bison were practically eliminated—thus removing the source of supply of the Plains Indians for food, fuel, shelter and clothing. This happening, together with cessation of Indian wars throughout the West caused an intense demand for beef on the reservations.

In 1881, the Atlantic and Pacific Railroad (Santa Fe) was completed through northern New Mexico and Arizona. About the same time the Southern Pacific Railroad was built westward along the Mexican boundary of these two states. The completion of the railroads gave added impetus to the build up in livestock numbers—this together with high prices during the period 1870-1885 resulted in the "beef bonanza" and the investment of much foreign capital mostly English and Scotch in the southwestern livestock industry. It was a period of easy money. Unbounded enthusiasm and optimism with regard to the future of the livestock industry was widespread. As an illustration of this, Patrick Hamilton on August 1, 1884, in Phoenix, Arizona, wrote the following:

> "Liberal estimates allow from 5 to 10 acres of grass to maintain an animal during the year. Taking the lowest figure which is a very conservative one, we have a total of 7,680,000 head which the grazing lands of Arizona are capable of maintaining. But even allowing 10 acres to each head and we have a total of 3,840,000. These figures are very reasonable and with the present growth of the cattle industry, it is very probable that the latter number will be grazing within the territory inside of 10 years."

Needless to say, the cattle business did expand greatly within the next decade, but it has never reached the magnitude predicted by this enthusiast.

The construction of the railroads led to rapid settlement through homesteading. It also led to a great deal of competition for land between the livestock industry and farming. A year following the Homestead Act of 1862 the Denver Land Office was opened. The Act itself favored farmers and not stockmen; but most of the Southwest was not suited for dry farming. As a consequence, in the years that followed, settlers searched out the most fertile land with live water. Rivalry for the latter was great because through control of water (and much land could be "protected" with the permitted 160 acre homestead which was later enlarged to 640 acres) one could control the adjacent range.

In Arizona the Apaches were subjugated in the early 70's and with the coming of peace the industry developed rapidly. In 1883 Colin Cameron introduced the first purebred Herefords into the San Rafael Valley in Arizona. Cattle numbers in the State as reported by Peterson ( ):

> "-----it is safe to say by 1870 there were 250,000 head. Their number grew steadily over the next two decades until there were nearly 1,000,000."

Another factor entering land settlement was the invention of barbed wire in 1874. It had a profound effect on the livestock industry in the Southwest. It made homesteading of vast treeless areas possible by enabling the settler to protect his crops from the grazing animals of the stockman. It meant the end of the open range and according to Webb ( ) blocked the cattle trails forcing "the cattlemen to patronzie the railroads whether he would or not." It, together with the development of the modern windmill made possible the further expansion of the livestock industry—through opening up formerly unwatered range. In six years from 1874 to 1880 annual manufacture of barbed wire increased from 10,000 to 80,500,000 pounds and the price dropped from $20 per hundred pounds to $10. The introduction of barbed wire also eventually emphasized the need for planned range management and better animal husbandry practices and encouraged the introduction of better beef breeds.

Thus the real impetus and buildup in livestock numbers in the Southwest, as elsewhere in the West, coincided with the completion of the railroads, the cessation of Indian wars, and the provision of a practical means of controlling grazing animals and providing water for them. In Texas, according to Brayer (2):

> "the cattle industry emerged from the destruction of the Civil War to the greater prosperity of latter 70's and ultimate boom and inflation of the early 80's, Texas changed from an open range state to one of vast privately owned and fenced ranges. Up to 1875 stockmen freely utilized the vast area of the State lands, which, though open to location were considered by the ranchers to be their own private preserves.--(Resulting) in Texas lands, in laws, and policies contributed to the breaking up of the ranges."

Another factor, affecting the development of the Cattle industry in the Southwest, was the quarantine laws resulting from the Splenic or Texas fever because, as Brayer (2) states:

> "It forced the Texans to turn to the West instead of the northern and eastern markets and aided materially in the founding of the industry in New Mexico, Colorado, Wyoming, Montana, and other states. (However)--fear of the disease led cattlemen in the range states to seek other sources than Texas for their basic stock--resulting in the development of the shorthorned breeds--the Shorthorn, Durham, Hereford and other stocks--in contrast with the longhorned Texas cattle. Texans made efforts to improve their own breeds."

With this first peak in livestock numbers several events took place--first a widespread drought in 1886 in the Southwest--then a series of severe winters throughout the West--and climaxed with too many livestock on the ranges, nearly prostrated the industry. In the panic of 1893 cattle and sheep sold for $1 per 100 pounds in Chicago. Brayer's (3) remarks on these happenings in New Mexico are pertinent and apply equally as well to other parts of the Southwest:

> "Drought and overgrazing began to take a severe toll of the ranges in the late 1880's. Unsettled market conditions, occurring with increasing frequency also contributed to the uneasiness and instability---."

In the sheep industry, development was extremely rapid after 1880. In New Mexico, for example, sheep numbers in 1882 reached a peak of 5.2 million head (about 60 years later - 1946 - they had dropped to 1.6 million). Competition of sheepmen with cattlemen for range was intense, often leading to violent quarrels and actual shootings.

The drought of 1886 relentlessly focused attention to the fact the range lands did not have limitless grazing capacity. But stockmen did not recognize "overgrazing"--only the fact that there was a shortage of "feed." Then, too, the stockman's early training was in the school of speculation--to make more money--run more livestock. Range management, as we know it today, did not exist and knowledge was gained only through bitter years of experience. In Arizona the drought of 1891-1895 was particularly severe with over 250 thousand cattle dying out of a total of 800 thousand. In Texas, as Brayer (2) observes:

> "Some 75 percent of the cattle companies in business in 1885 had failed or otherwise withdrawn from the livestock business by 1905."

Frequent periodic death losses (25 to 50 percent were not uncommon) from starvation and poisonous plants led to numerous requests by stockmen to Congress for assistance in solving such problems as: (1) How to increase range forage by reseeding, (2) how to eradicate the invading undesirable and often poisonous plants. In 1898 $15,000 was appropriated for the Bureau of Plant Industry "for grass and forage plant investigations."

Thus, within 10 years' time following the first peak in livestock numbers in the late 80's, we find stockmen requesting assistance on range problems and recognition of this need by the Federal government. At the turn of the century we find several range observers recording with alarm their views of too many livestock and resultant range deterioration. In this respect the observations of Bentley( ) made in 1898 on the "exhaustion of pasturage in the Southwest" are of interest:

> "This overstocking of the ranges has continued year after year, through good seasons and bad ones, until it is the opinion of some of the most experienced cowmen of Central Texas that the injury has gone almost past the point where redemption is possible. The ranges have been almost ruined, and if not renewed will soon be past all hope of permanent improvement.
>
> Not only have the ranges been overstocked, but the prairie dog and the jackrabbit have also been damaging the land until the best natural grass country in the United States has been almost destroyed. It is not yet too late to remedy the evil, but no time is to be lost. It is the common opinion that rest is all that is necessary to recuperate and bring back the former luxuriant vegetation of the ranges. But in part common opinion is here at fault. Resting the range will greatly help it, but something more must be done to bring it back to its original capacity for supporting stock, if, indeed, that is now possible. The people of Texas are not different from those of other states. They are all alike grass destroyers."

A resolution passed, "without a dissenting voice and with a shout," at a stockmans meeting, as reported by Bentley (in 1898) is expressive of the spirit and philosophy of the time:

> "Resolved, that none of us know, or care to know, anything about grasses, native or otherwise, outside of the fact that for the present there are lots of them, the best on record, and we are after getting the most out of them while they last."

The remarks of Smith ( ), a botanist, made a year later are more specific as to the nature of range deterioration and what might be done in the nature of management to improve the range:

> "....the best grasses were eaten down to their very roots, the roots were trampled into the earth, and every green thing was cut down so that it could neither ripen seed, and thus perpetuate its kind, nor recover from the trampling and exposure of its roots to the air and sun. The recuperative power of the grasses was lessened or destroyed, and weedy species which were present before, but which had been held in check by the luxuriance of the better, dominant sorts, immediately increased in number by rapid bounds. So also the mesquite bean and the cactus, both of which may be destroyed by fire, grew in numbers and commenced to crowd out the grasses.
>
> There are many square miles of territory in the Southwest where the ruthless destruction of grass has been carried to the extent mentioned above. The grazing capacity of large bodies of land has been reduced within a period of twenty years from one head to 2 to 5 acres, to one head to 20 or 25 acres. As late as 1883 from 128 to 320 head of cattle could be supported on a single section, where to support a like number now requires from 4 to 12 square miles. Where the conditions have been especially unfavorable, stockmen report that it sometimes requires 60 acres per head, and the land there is almost bare of vegetation. Such denuded areas occur in New Mexico and Arizona, and are due almost entirely to the ruthless destruction of free grass on public lands.
>
> The chief cause of overstocking in the first place was the free-range system, under which lands owned by the State, public institutions, or corporations, under the common law and in the absence of the owners or their agents, were considered as commons upon which any man was free to pasture all the cattle or sheep which he could command. The holding or use of lands in common always results in rapine, because of the principle that what is everyone's property is no one's, and no one is responsible for its abuse and spoliation.
>
> Partial resting, or resting during different seasons of the year, a system which may be designated the alternation of pastures, secures the same result at much less expense. Thus a range might be divided up into a number of small pastures provided with water, in each of which the cattle would be allowed to run for not more than two or three months at a time and then be transferred to another. In this way the succession of grasses which normally occurs in nature can be fostered and improved. Let us suppose a range of 100,000 acres in extent divided into ten pastures of 10,000 acres each. At the average carrying capacity for the State this body of land will produce forage enough to sustain 10,000 stock cattle throughout the year. These divided up into their various classes--beef steers, two-year olds, and yearlings, cows and calves--could be held three months in one pasture and then transferred to another which had been kept free from stock during that length of time. A rest of two or three months during the growing season in early spring

> would enable the early grasses to ripen and shed their seeds, thus perpetuating the early species. After the seed had fallen the cattle could be turned on the grass for two or three months and again transferred to a fresh pasture. In the same way autumn and winter pastures can be secured. Several stockmen who have employed this method on a large scale for a number of years say that their ranges are continually improving, in marked contrast to the deterioration that had occurred through bad treatment of neighboring properties where the old methods were practiced."

Period since 1900.--Only a brief description of this period in the history of the livestock industry appears necessary as background material to a better understanding of the origin of range problems in the Southwest. Whenever necessary, however, pertinent and significant references will be cited in subsequent sections.

In the first decade of the 20th century we find stockmen beginning to recognize range deterioration as such and taking a more realistic attitude as to its causes. Furthermore, range observers were attempting to spell in specific terms the nature of this deterioration. The observations of Wooton ( ) bear out these points:

> "The second report of the Public Lands Commission (Senate Document 189 (1905), p.7, and the reprint in Forest Service Bulletin 62, p. 13) shows that of 118 stockmen of New Mexico reporting upon the ranges they know, 102 believed that the carrying capacity of these ranges had diminished while only 16 reported that their ranges had increased in carrying capacity. Of this number 69 believed the diminution was due to overstocking and 33 to drought. Since overstocking tends to produce drought this second answer may be at least merely another way of saying that overstocking probably produced most of the loss in carrying capacity.
>
> Hence an area occupied by plants which stock will not eat, in a region where good forage plants should grow well, tells something of the past history of the area. Of the valueless plants thus occupying good land and telling of the past suffering of the range, several are quite characteristic. The prickly poppy or poppy thistle (Argemone spp.) and the wild tobacco (Nicotina attenuata Torr.) not infrequently occupy large areas, from which everything else has been driven out; they particularly like open arroyos and draws, which have resulted from too rapid running off of the rains

> and melting snows. Two others of equal importance and frequency are the Rocky Mountain bee plant (Cleome serrulata Pursh) and Croton texensis (Klotzsch) Muell. Perhaps the most important weed of this kind, which is taking thousands of acres of our higher plains, is what is known in various localities as sheep weed, snake weed, or yerba del vibora. Thus it is possible by looking at a range to tell how it has been treated. The number and kinds of range weeds, the kinds and abundance of grasses, the condition of the shrubbery, the amount and character of the erosion features, all taken together with an appreciation of the common or typical condition of the locality in question, tell the story of what the range has been, and hence what it may be again by proper treatment.
>
> Thus other effects of overstocking are to make the land so that it will not absorb the water that falls; to hasten the run-off of the water and give it little opportunity to soak in; to use the force of this run-off to carry away the loose and lighter parts of the soil, thus rendering the region less able to grow forage; and at the same time to render the surface more uneven and better fitted for occupancy by range weeds. The careful observer is able to tell pretty accurately the treatment the range has received by simply riding over it and seeing thekinds of plants present, the relative abundance of each, the condition of the trails and roads, and the number and size of rocky or gravelly arroyos. Each tells its own story of too much stock."

In Arizona and New Mexico a stabilizing influence on the part of the industry using the forested ranges was the establishment of the national forests in the early 1900's. Federal control has undoubtedly rendered conservation to much land that would otherwise have been misused and has helped encourage better use of other rangelands elsewhere in the region. However, after some 40 years of administration of national forest lands much remains to be accomplished in the adoption of better range and livestock management and in range improvement through reseeding, noxious plant control, cross-fencing and water development.

The period since 1900 is well covered in Brayer's (2) remarks on the cattle industry in Texas since in general these apply equally as well to other parts of the Southwest:

> "A reorganized industry began in 1894 to condition itself to the situation. (Overstocking) The longhorn rapidly passed from the scene as cattlemen found the new range-feeder conditions better suited to the heavier well bred white-faced Herefords. A sharp improvement in the price of cattle brought another prolonged period of depression.---although the number of Texas cattle never approached the peak of 9,805,000 noted in 1891, the average price per head improved materially from 1906 through the period of the first World War when, in 1920, an all time high of $43.90 was recorded. Texas cattle showed marked improvement in quality during this period, with purebred stock from local herds finding ready markets in other cattle raising states.---Texas ranges suffered materially during the period preceding the outbreak of the second World War, but the combined cooperation of stockmen and their organizations with the conservation and rehabilitation programs of both State and Federal governments placed the Texas industry in the position to render an invaluable contribution to victory. The more than 7,500,000 head of fine beef stock now on the Texas ranges will do much to rehabilitate and revitalize the starved and exhausted war torn countries of the world."

Although there may be some question regarding Brayer's optimism about the present and future capacity of Texas ranges unless present efforts at range improvement are greatly expanded, he nevertheless adopts a more realistic viewpoint in another article (3) related to New Mexico ranges:

> "The future of the cattle industry in the Sunshine State is not too promising. Much will depend upon National tariff policies and the ability of the industry to maintain full employment. Another difficulty will be to overcome the decline in grazing capacity of range lands. After World War I it was evident that ranges in the State were then seriously overstocked. In 1924 many cattle had to be moved into Mexico because of a critical feed shortage. This condition improved somewhat during the 30's but demands of World War II have again aggravated this situation."

Significance of historical events.--The foregoing review of the historical background of grazing use by domestic livestock and their influence on the range is admittedly sketchy. Much additional research into the voluminous archives of the early Spanish and Mexicans and the later Anglos is warranted to reconstruct the picture of vegetation and fauna, character of streamflow and erosion before the advent of livestock. It is important to know what these pristine conditions were in order to correctly appraise the character and extent of deterioration that has transpired and to judge the full potentialities of the range. In spite of our meager historical summation, several events appear remarkable as well as significant from the standpoint of their impact on the range resource. First of all one is forced to conclude that since the time of the coming of the white man to the Southwest, vast and far reaching changes have occurred in the vegetation. As will be substantiated in the following pages, these changes are not conjecture, they may take place within the relatively short time of half a century and they are still occurring. Witness, as one example, the millions of acres of formerly open grasslands of Texas and southern Arizona now covered with low value mesquite.

The historical record indicates prior to the advent of domestic livestock the bulk of our range lands were in the climax or sub-climax stage of plant succession. This does not mean that the grass was necessarily stirrup high everywhere and that regardless of the storm pattern that all streams flowed evenly and clear at all times. It does mean, however, that total forage production per unit area was about as great as the climate and soil fertility would produce, the nutritional level of the forage because of the wide diversity in grass species was higher and covered a larger span in the year, that the plant cover was adequate to not only hold the soil in place but was conducive to its gradual increment and upbuilding in fertility. Although the changes in vegetation have resulted in a greatly lowered potential for livestock production and the reduced fertility of extensive areas, still the dire prediction of Bentley ( ) that all the range has been ruined beyond "the point where redemption is possible" has not proven true.

We have seen that the first domestic livestock were brought into the Southwest by the early Spanish, that the grazing of these livestock was confined largely to the areas adjacent to live water and under the protection of the mission fathers; that the real impetus in the buildup of livestock numbers did not take place until some two hundred years later with the construction of the railroads and the cessation of Indian Wars, that the invention of barbed wire and the windmill permitted grazing use of extensive areas formerly inaccessible to livestock, and that with the first peak in livestock numbers the problems of inadequate forage, poisonous plants and invasion of undesirable plants began. The great variations of grazing use with respect to length of time, season of use and intensity has resulted in a crazy quilt pattern of lands varying widely in range conditions. These widely varying conditions, in the several major range types, pose many different problems in improvement through management, reseeding and noxious plant control. It is the hope of the future and the job of research to find adequate practical means for their solution.

●

ECONOMIC IMPORTANCE OF THE RANGE LIVESTOCK INDUSTRY

In considering the economic importance of range livestock in the Southwest it should always be borne in mind that nature has endowed us with vast areas of lands which are too rough, or rocky, or too dry to be successfully cultivated for crops. Food production on these lands will always remain an indirect one, related to the conversion of grass and other range forage into meat and other animal products.

The range livestock industry is an important segment of the agricultural economy of the Southwest. As shown in Table 2, in 1945 cattle numbers were 3.5 million, sheep 6.6 million, and mohair goats 2.2 million. The bulk of these animals were produced from range forage and represented a gross income of 190 million dollars. This is about a third or more of the total income from farms and ranches. Numbers of livestock in the Southwest represent about one-fourth of the cattle, more than a third of the sheep and more than half the mohair goats in the eleven Western States. Nationally, they comprise about 9 percent of the beef cattle, 14 percent of the sheep and 51 percent of the mohair goats.

Table 2. Number of Livestock* in the Southwest

	Total SW (000)	Arizona (000)	New Mexico (000)	Western Texas and Oklahoma panhandle (000)
Cattle	3496	749	1091	1656
Sheep	6639	511	1617	4511
Goats (mohair)	2190	90	146	1954

*1945 - Dept. of Commerce - Bureau of the Census.

Western Texas and the Oklahoma panhandle, which together comprise some 80 million acres, form the most productive part of the Southwestern range. In this area are raised about the same number of cattle, more than twice the sheep and nearly ten times the number of mohair goats as in Arizona and New Mexico combined.

The bulk of the livestock are marketed in the fall, going to the feed lots, irrigated pasture, or direct to slaughter. Fort Worth, Kansas City, Denver, and Los Angeles are the most popular markets. The Pacific Coast with its rapidly expanding human population is becoming more and more dependent on the Southwest as well as other Western States to fulfill the demands of these people for meat.

Significance of Trends in Livestock Population.--The history of the development of the livestock industry and accompanying range deterioration in the Southwest has been covered in general terms. A study of the feedproducing capacity of both range and farm land, and trends in livestock numbers, is equally enlightening. Material prepared by Selby and Griffith ( ) is especially to the point and is presented in Figures 2 and 3. These charts indicate the general long time trends and "the proportionate amounts of feed obtained from range and from feed produced on farms; in the use of farm lands for pasture, feed crops, and other crops; in the proportionate numbers of different kinds of livestock raised; and in the relative importance of potential irrigation development" in Arizona and New Mexico. Study of these charts reveals several significant points in both states:

1. Livestock numbers reached their first peak in the late 80's.

2. Greatest livestock population was reached during World War I. This was an unfortunate event since numbers exceeded the forage and feed supply (although the charts do not show this); the expected and needed

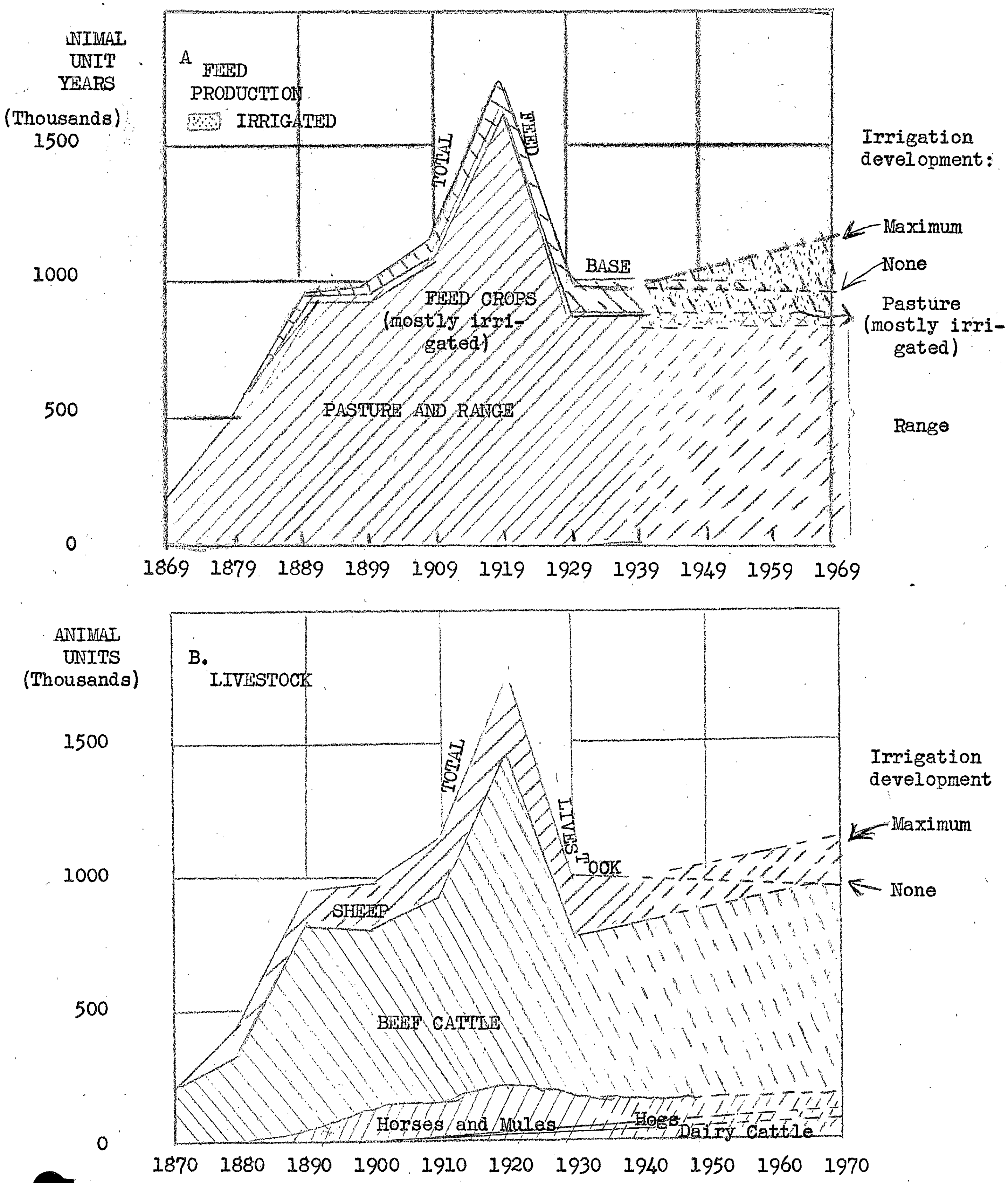


Figure 2. Arizona: Estimated past trends in feed-producing capacity and livestock number, and relation of potential irrigation development to possible future trends. (From Selby and Griffith)

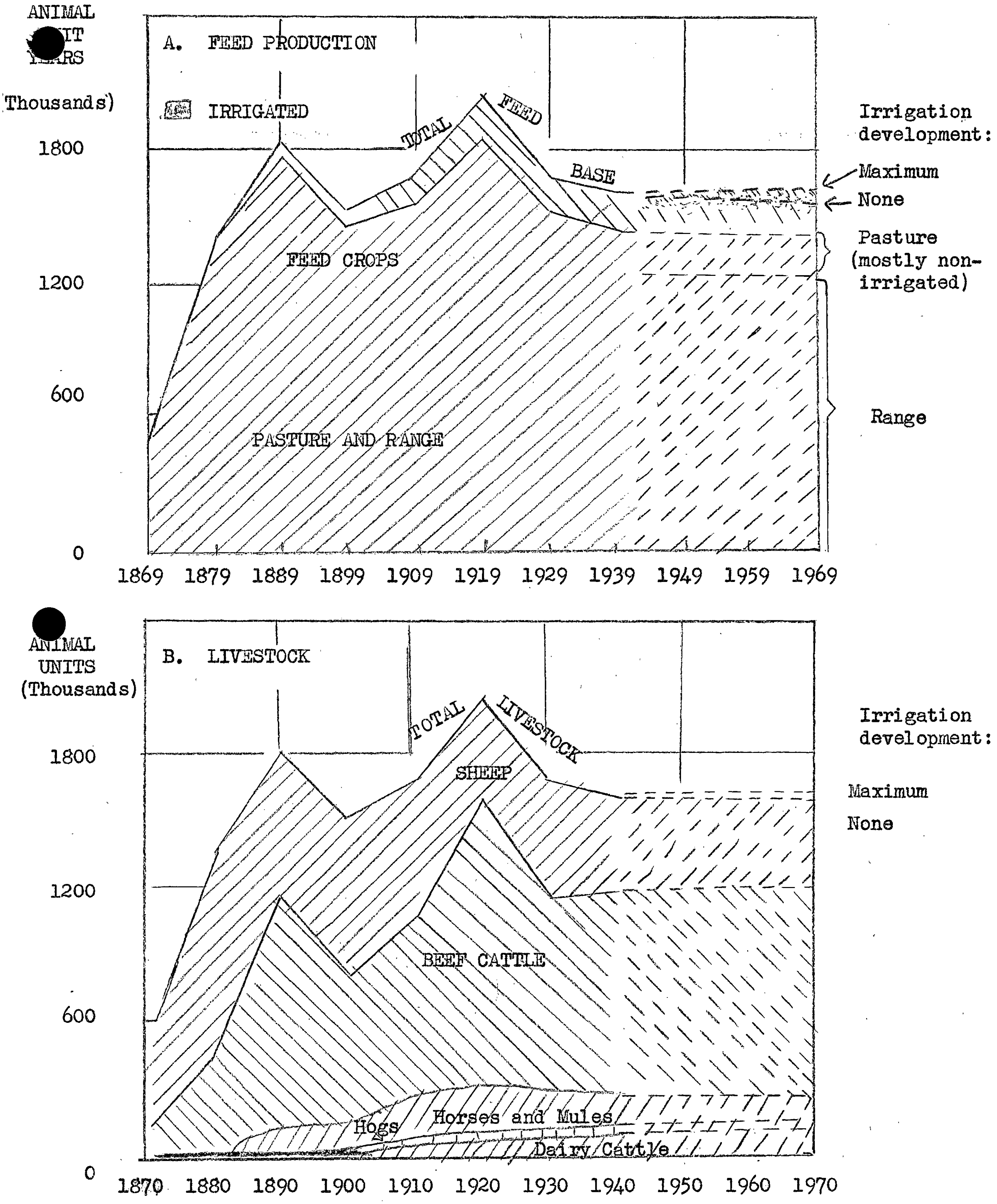


Figure 3. New Mexico: Estimated past trends in feed-producing capacity and livestock numbers, and relation of potential irrigation development to possible future trends. (From Selby and Griffith)

wartime production of meat was not realized; serious range deterioration resulted and stockmen suffered heavy financial losses in the early 20's.

3. Downward trend in livestock numbers since 1920.

4. Present range livestock numbers are comparable to those of the early 80's but the capacity of the range to support livestock is undoubtedly a good deal less. In the 80's there were (a) little or no fencing and water development, (b) no supplemental feeding, (c) animals were of poor quality and breeding. Although light in weight as judged by present day standards, they were commonly marketed by the head as 2 and 3 year olds, (d) nearly all animals were maintained exclusively on the range. On the other hand, by 1948 there have been marked changes: (a) improved management and livestock handling practices aided by much fencing and water development, (b) supplemental feeding is a common practice, particularly during drought, (c) animals are of good beef breeding, marketed by weight as calves, (d) nearly 20 percent or more of the livestock are supported on pasture in the irrigated and dry farming areas and dairy cattle have become locally important.

5. Future possible increase of feed supplies in New Mexico (likewise true in west Texas) through irrigation development is small. In Arizona this could become a significant factor in supporting present numbers and even encouraging an increase.

The main conclusion would seem to be that the capacity of the range to support livestock is a good deal less than it was in the 1880's. Selby and Griffith ( ) recognize this, but state that "part of the decline in the amount of feed obtained from the range may be attributed to policies of reducing the permitted grazing on some publicly-owned range areas relatively more than the degree of the deterioration in the range, for such purposes as protection of watersheds, rehabilitation of overgrazed areas, and development of recreational areas." This is true but not of great consequence when one recalls that the 20 million acres of National Forest land in the two states represent 13 percent of the area and support 13 percent of the cattle and about 11 percent of the sheep. Most of this forest range country is rough and mountainous, producing the four major crops of water, forage, timber and wildlife. Furthermore, about 25 percent is seasonal range, limited by climate to a 5 months' or less grazing period.

Character of Ranching Operations.--The Southwest is essentially a breeding country wherein the cattle industry is concerned. Cow and calf operations predominate. Calves and yearlings are the principal source of income; the bulk of the calves being marketed in the fall. Steer grazing is practiced on some areas where spring forage is available and on the summer ranges. Bulls are kept with the breeding herd most of the year and this results in lack of uniformity of calf production. However, the bulk of the calves are dropped in the spring because of the nutritional characteristics of the forage.

Dependency on yearlong range use, combined with relatively low grazing capacity, have fostered extensive ranch holdings. Range forage is characteristically deficient in protein and phosphorus during the winter months and in the spring dry periods. Supplemental feeds, usually cotton seed cake, meal or hulls which are high in protein, and phosphorus, are fed only during droughts. Hence, cattle are seldom "grass fat." The lack of adequate feed supplies is largely responsible for the production of feeder or stocker cattle. However, the production of finished beef is becoming an established enterprize in the irrigated areas and in the dry farming sections of eastern New Mexico and western Texas. Hereford cattle are used almost to the virtual exclusion of all other beef breeds. There are some Angus and Shorthorn herds and in the warmer, southern portions of the region interest is developing in the Brahma--especially in crosses with grade Herefords.

In Arizona and western New Mexico both sheep and goats are grazed under the herder system. On the better managed ranges a high percentage of lambs come off as grass fat. In Eastern New Mexico and Texas they are grazed loose inside fenced pastures. Sheep are mainly of the Rambouillet breed. In the irrigated and other feeding areas there is some crossing with medium wool breeds such as the Hampshire and Suffolk. Milk-fat "Easter lambs" are produced in the Salt River area of Arizona. On the Indian Reservations of northern Arizona and northwestern New Mexico a mixed breed producing coarse, light wool, adaptable to rug weaving, are favored. Goats are chiefly Angora, bred for mohair production.

In Arizona, and most of New Mexico, ranching is exclusively cattle, or sheep or goats -- seldom are two or more kinds of livestock grazed on the same range. In southeastern New Mexico there is some dual use with cattle and sheep. In Texas it is not uncommon to graze cattle, sheep and goats together. This is done on the theory that it is the most efficient way to use the range since cattle prefer the grass, sheep eat the weeds and goats feed upon the browse. The practice generally has destructive effects on the range.

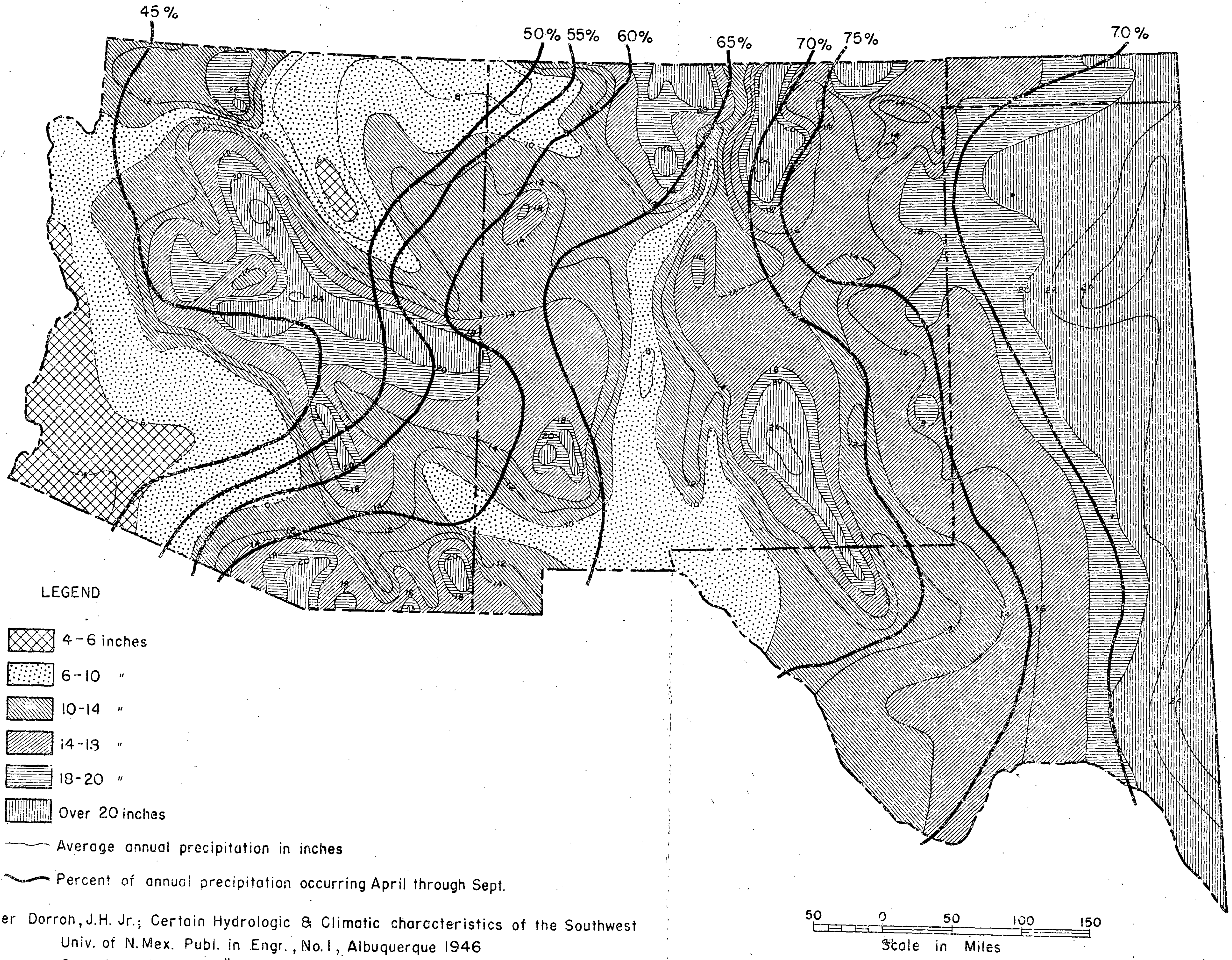
CLIMATE

Climate in the Southwest is typically continental and covers a temperature range from sub-tropical to artic (above timberline). Elevations range from 137 feet above sea level along the Colorado River in Arizona to well above 13,000 feet in the Sangre de Cristo range of northern New Mexico. Precipitation is the most important factor influencing the kind of vegetation and character of forage drowth. In general the plant growth becomes more highly developed and varied with increase in elevation. Average annual precipitation varies from about 3 inches (and this may occur in one storm) in the desert portions of southwestern Arizona to well over 35 inches in the higher mountains. The bulk of the region receives 10- to 18-inches of rainfall, as shown in Figure 4.

Seasonal distribution of precipitation is variable. In western Arizona less than 45 percent of the yearly precipitation occurs during the period extending from April to September inclusive, whereas the percentage increases to more than 75 in eastern New Mexico over the same span of months. Drought frequency (precipitation 75 percent of average or less) varies from about one year in ten in the Oklahoma panhandle to three to four years of each 10-year period in southwestern Arizona, according to Campbell (   ). However, even in years of above average rainfall, throughout large portions of the entire region soil moisture is so low that it is unavailable to vegetation month after month. Fluctuations in precipitation result in corresponding variations in forage production thus creating the major range problem of securing a proper balance between forage supplies and the feed requirements of livestock.

Figure 4

AVERAGE ANNUAL and SEASONAL PRECIPITATION SOUTHWESTERN REGION*


45%
50%
55%
60%
65%
70%
75%
70%
LEGEND
4-6 inches
6-10 "
10-14 "
14-18 "
18-20 "
Over 20 inches
Average annual precipitation in inches
Percent of annual precipitation occurring April through Sept.
50 0 50 100 150
Scale in Miles

*After Dorroh, J.H. Jr.; Certain Hydrologic & Climatic characteristics of the Southwest
Univ. of N.Mex. Publ. in Engr., No. I, Albuquerque 1946
Data for Texas from "Climate and Man", USDA Yearbook of Agric., 1941

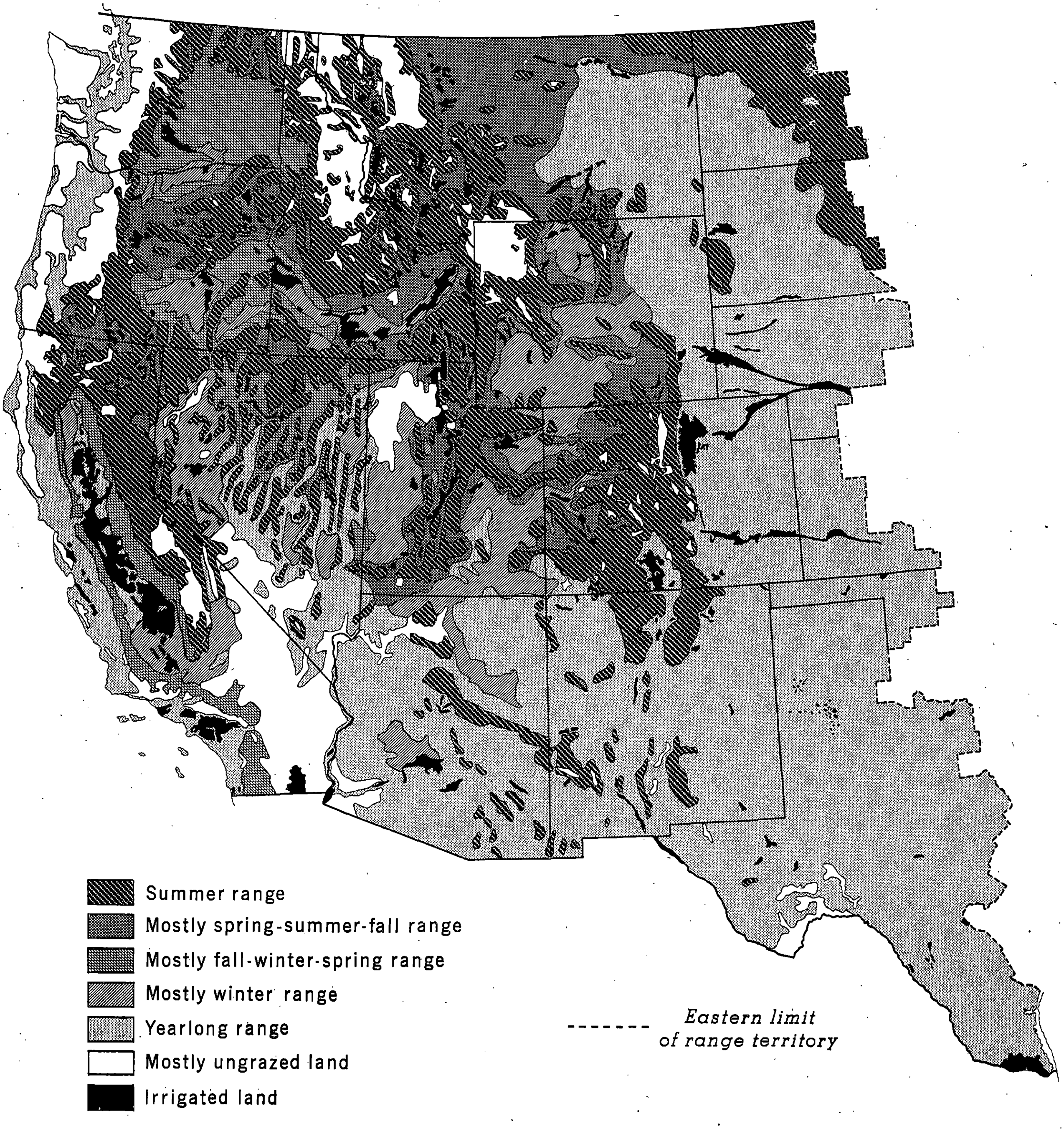
Length of growing season, which is based on the number of days occurring between the last killing frost in the spring and the first severe frost in the fall, varies from less than 90 days in the northern to over 200 days in the southern portions of the region. In fact southwestern Arizona is nearly frostfree. Summer temperatures frequently exceed 100 degrees F., relative humidity is characteristically low and evaporation exceedingly high. For example, at the Santa Rita Experimental Range, total annual evaporation from a free water surface reaches 107 inches. High evaporation, combined with erratic, fluctuating precipitation makes forage growth and plant establishment exceedingly uncertain.

Yearlong grazing of both cattle and sheep characterizes the Southwest ranges as shown in Figure 5. Generally mild and open winters permit this constant usage. In fact it is necessitated by limited crop farming and isolated irrigated areas. Seasonal ranges are determined by climate and confined largely to Arizona and New Mexico. Summer ranges are on the high mountain forested areas where the season is limited to about five months or less. Winter ranges, mostly in Arizona are of two types; the northern sagebrush desert on the Arizona Strip, (see p. 32) (used in connection with the summer ranges of Utah) and the desert ranges of southwestern Arizona. The latter can and have been used on a yearlong basis but it is a precarious practice because of the uncertainty of winter-spring forage growth and the lack of stock watering facilities.

The general aspects of the climate in the Southwest are well described by Arnold (   ).

FOR ONE PAGE USE ONLY

SEASONAL USE OF WESTERN RANGE, 1947


▨ Summer range
▨ Mostly spring-summer-fall range
▨ Mostly fall-winter-spring range
▨ Mostly winter range
▨ Yearlong range
☐ Mostly ungrazed land
■ Irrigated land
------- Eastern limit of range territory

BUREAU OF AGRICULTURAL ECONOMICS IN COOPERATION WITH THE U. S. FOREST SERVICE

EPARTMENT OF AGRICULTURE NEG. 46520 BUREAU OF AGRICULTURAL ECONOMICS

Figure 5.--Yearlong grazing use by livestock characterizes most ranch operations in the Southwest.

VEGETATION AND SOILS

Wide variation in precipitation, temperature, evaporation, elevation, length of growing season and of soils have resulted in a diversity of vegetation types in the Southwest. Because of these major variations in climate and soil, which are often found within relatively small areas, one may, in the space of a few hours, encounter the desert covered with creosotebush, then the semi-desert grassland, and a few miles away, the pinyon-juniper woodland or even the ponderosa pine forests. On the other hand it is possible to travel seemingly unending distances in the same vegetational community as for example the shortgrass plains of western Texas and eastern New Mexico. A full description of the various vegetational communities in the Southwest is given by McGinnies et al (   ).

The characteristics of the major range types in the Southwest are shown in Figure 6 and are listed in Table 3 with respect to location, extent, annual precipitation, season of grazing use and important forage species. These range areas will be discussed in the section entitled "Major Range Areas - Characteristics and Problems." This section will also include data on the floristic composition of the vegetation, deterioration of plant cover and soils, land use values and range problems peculiar to each range province.

The nature of the soil is dependent on climate, vegetation, time and the geologic origin of the parent material. Since these factors vary widely in the Southwest, the soils are as diverse as the vegetation. Specific information on the characteristics of southwestern soils is generally lacking and the few soil surveys that have been made are mostly on the cultivated areas of the state. References

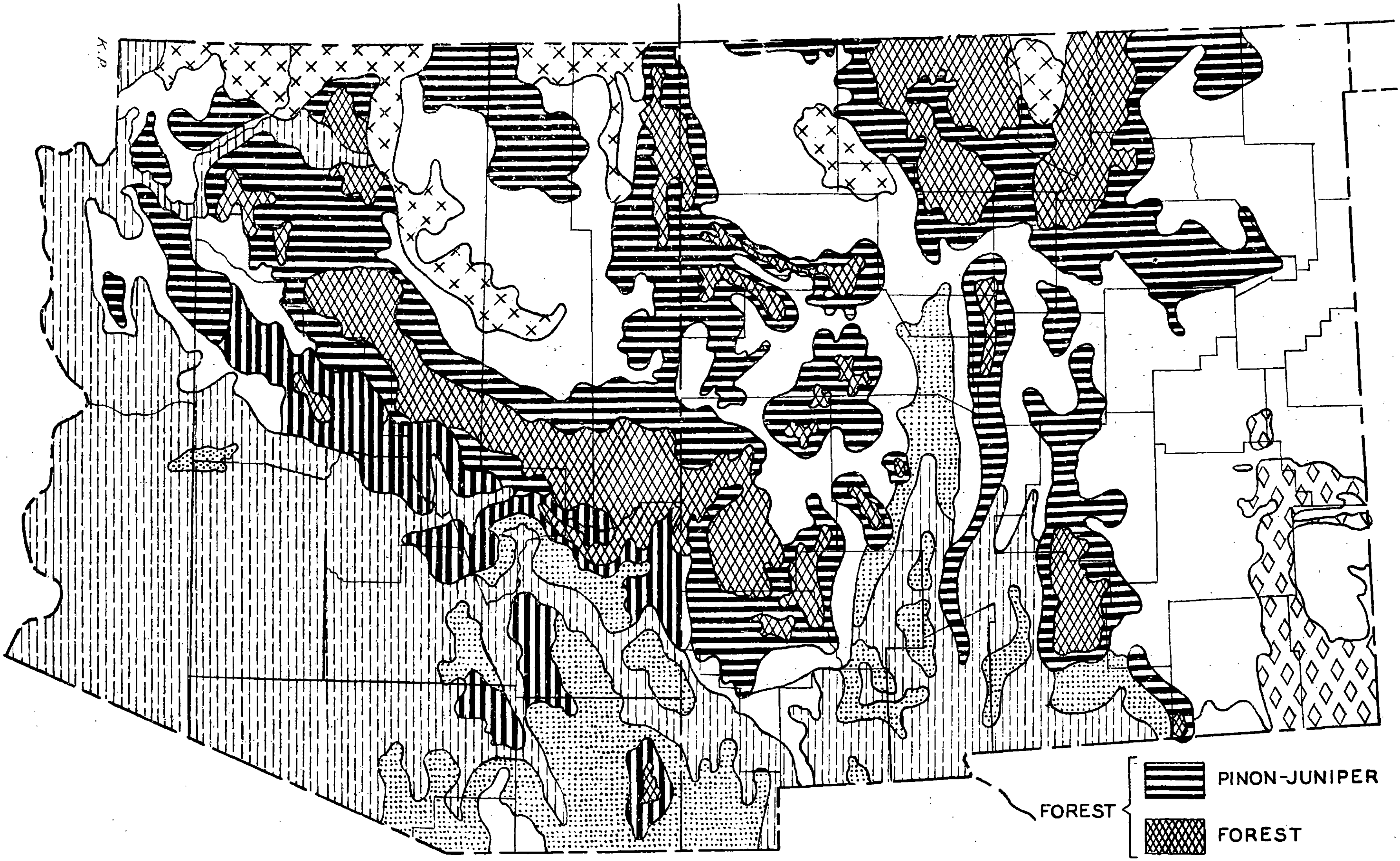

K.P.
FOREST
PINON-JUNIPER
FOREST

FIGURE 6.— NATURAL VEGETATION TYPES IN THE SOUTHWEST

GRASS
SHORT GRASS
DESERT GRASSLAND & MESQUITE GRASS
SHRUB
SOUTHERN DESERT SHRUB
NORTHERN DESERT SHRUB
CHAPARRAL & OAK WOODLAND
SHINNERY OAK

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Table 3. Characteristics of major range types in Southwest

Major range type	Location	Percent of regional area	Elevation range (feet)	Annual precipitation (inches)	Season of grazing use	Prominent species	Important forage plants
Ponderosa pine bunchgrass	Ariz., N.Mex.	7.8	6,000 to 11,000	17-35	Summer	Ponderosa pine	Arizona fescue, mt. muhly, pine dropseed, bluegrasses, blue grama
Pinyon-juniper woodland	Ariz., N.Mex., Texas	14.3	4,500 to 6,500	10-17	Yearlong: spring-fall winter	Pinyon, pines, junipers, oaks	Mt. mahogany, bitterbrush, cliffrose, big sagebrush, wheatgrasses, bluegrasses, needlegrasses, Indian ricegrass, blue and sideoats gramas, galleta
Semidesert grass	Ariz., N.Mex., West Texas	25.8	Below 5,000	8-15	Yearlong	Grama grasses	Black grama, tobosa, curlymesquite, dropseeds, galleta, bush muhly, Rothrock grama
Shortgrass	Ariz., N.Mex., West Texas	34.4	4,500 to 7,500	15-20	Yearlong	Grama grasses	Blue, hairy, and sideoats gramas, dropseeds, galleta, black grama, bluestem wheatgrass, curlymesquite
Sagebrush-Grass	Northern part Ariz., N.Mex.	7.5	2,500 to 6,500	8-15	Spring-fall winter	Big sagebrush	Big sagebrush, wheat grasses, bluegrasses, Indian ricegrass, Arrowleaf balsamroot
Southern desert shrub	Ariz., southern N. Mex., West Texas	10.2	Below 5,000	3-12	Winter yearlong	Creosotebush	Black grama, tobosa, dropseeds, big galleta, chamiza, mesquite

best summarizing the characteristics of range soils are Martin and Fletcher ( ), McGinnies et al ( ), and Arnold ( ). There has been little or no work such as that of Sinclair and Sampson ( ) in correlating the occurrence of plant species with soil horizons. Such work is needed to obtain a better understanding of the fertility of Southwestern soils and plants best adapted to these various levels of fertility in order to permit the furthering of land conservation programs. This research is a must for any effective program of reseeding research.

The susceptibility of soils to erosion is controlled in a large degree by topography, soil texture, vegetational protection, rainfall, land use and other factors. The Soil Conservation Service in the Southwest has made a broad classification of soils according to susceptibility to erosion and deterioration. Preliminary information secured indicates that: less than 3 percent of the range area is not subject to deterioration; 30 percent is slightly subject to deterioration and can be conserved through proper management, with only a minor amount of range improvement work, such as fences and water development; but two-thirds of the total range area will require especially careful management and may, in many instances, require substantial mechanical control of accelerated erosion.

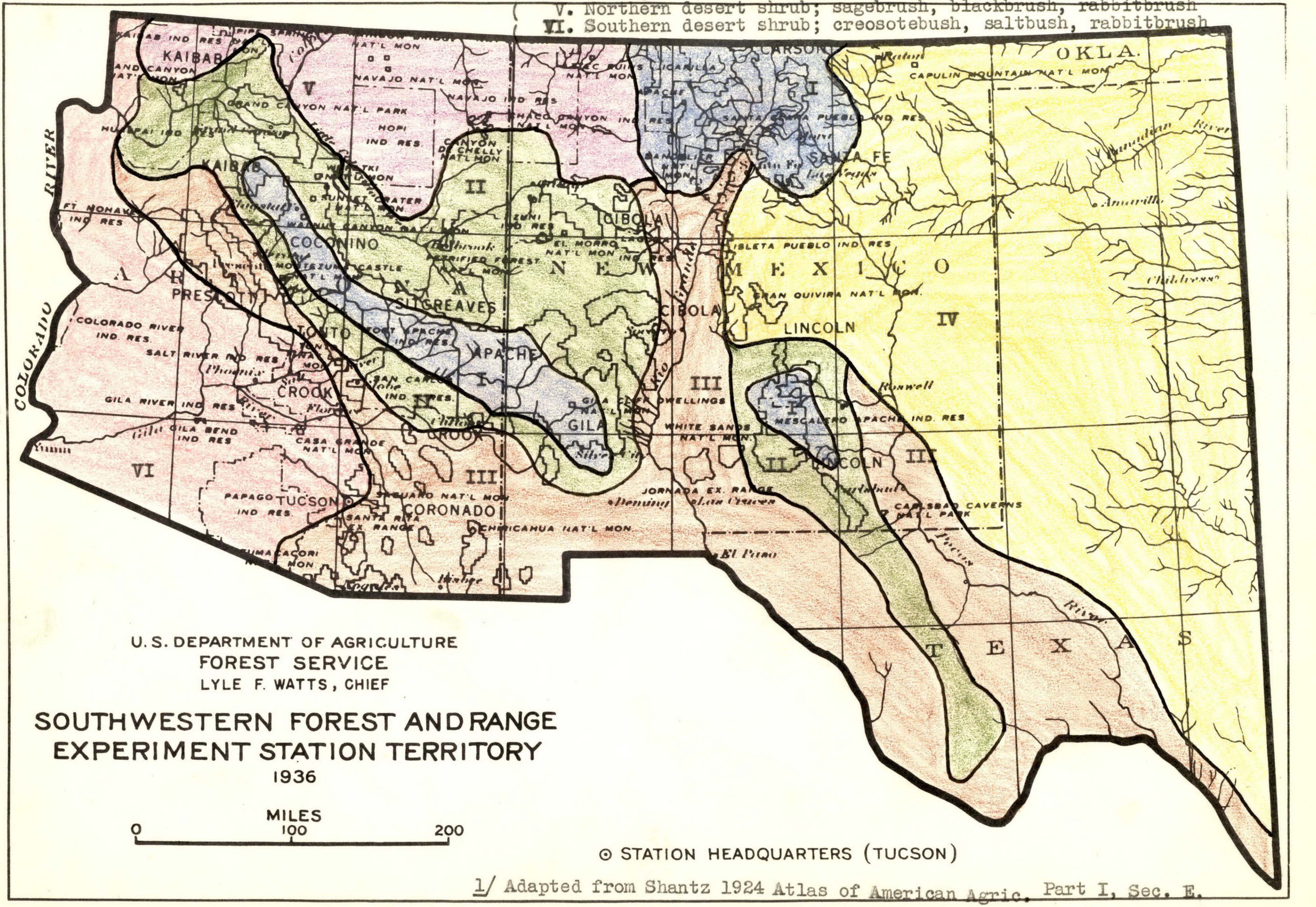
MAJOR RANGE AREAS
CHARACTERISTICS AND PROBLEMS

Six major range areas, provinces or zones in the Southwest are recognized in this problem analysis. Each of these areas has been delineated on the basis of the dominant type of vegetation characteristic of the area. These provinces are obviously so broad that each one includes some land which is typical of other vegetational communities, often in substantial amounts and greatly intermingled. A summary of the main characteristics and factors such as area, elevation, precipitation, value for timber, watersheds, wildlife, recreation, range, and general status with respect to past and present range research and urgency of future research is presented in Table 4 (see page). Specific details of the characteristics of each area and major range problems are presented in the following pages. The range areas described are identical with the six major reseeding zones recognized and discussed in the problem analysis on range reseeding prepared by Glendening and Parker ( ). (See fig. 7).

Estimates of deterioration in each of the six major range provinces are mostly those made by McArdle et al ( ) in 1936. Presumably there has been some change in range condition for better or worse since these estimates were made. On many individual ranching units the trend in range condition has been unquestionably upward. How much this has affected the trend on a regional or even on a range province basis is unknown. Progress has been made in securing a general awakening to the problem of range deterioration through the conservation programs conducted by the Agricultural Adjustment Administration, the Soil Conservation Service, the Forest Service, and various other federal and state organizations. The public works programs and various subsidies have stimulated the construction of many range

Figure 7.--Major range provinces in the Southwest 1/

Legend
- I. Open forest, pine and fir fescue, muhly
- II. Woodland; juniper, pinyon, oak, blue grama, galleta, bluestem
- III. Semidesert grassland; mixed grama, mesquite, creosotebush
- IV. Shortgrass; blue grama, buffalograss
- V. Northern desert shrub; sagebrush, blackbrush, rabbitbrush
- VI. Southern desert shrub; creosotebush, saltbush, rabbitbrush


I
II
III
IV
V
VI
KAIBAB
KAIBAB
CARSON
SANTA FE
CIBOLA
COCONINO
SITGREAVES
APACHE
TONTO
PRESCOTT
CROOK
GILA
LINCOLN
CORONADO
TUCSON
OKLA.
NEW MEXICO
ARIZONA
TEXAS
COLORADO RIVER
GRAND CANYON NAT'L PARK
NAVAJO IND RES
HOPI IND RES
CANYON DE CHELLY NAT'L MON
CAPULIN MOUNTAIN NAT'L MON
ISLETA PUEBLO IND RES
GRAN QUIVIRA NAT'L MON
MESCALERO APACHE IND RES
WHITE SANDS NAT'L MON
JORNADA EX. RANGE
CARLSBAD CAVERNS NAT'L PARK
GILA CLIFF DWELLINGS NAT'L MON
FT APACHE IND RES
SAN CARLOS IND RES
GILA RIVER IND RES
SALT RIVER IND RES
COLORADO RIVER IND RES
FT MOHAVE IND RES
HUALPAI IND RES
GILA BEND IND RES
PAPAGO IND RES
CASA GRANDE NAT'L MON
SAGUARO NAT'L MON
SANTA RITA EX RANGE
CHIRICAHUA NAT'L MON
TUMACACORI NAT'L MON
EL MORRO NAT'L MON
ZUNI IND RES
PETRIFIED FOREST
MONTEZUMA CASTLE NAT'L MON
WALNUT CANYON NAT'L MON
SUNSET CRATER NAT'L MON
WUPATKI NAT'L MON
NAVAJO NAT'L MON
CHACO CANYON NAT'L MON
JICARILLA IND RES
BANDELIER NAT'L MON
Phoenix
El Paso
Roswell
Amarillo
Childress
Pecos
Rio Grande
Deming
Las Cruces
Canadian River

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
LYLE F. WATTS, CHIEF

SOUTHWESTERN FOREST AND RANGE EXPERIMENT STATION TERRITORY
1936

MILES 0 100 200

⊙ STATION HEADQUARTERS (TUCSON)

1/ Adapted from Shantz 1924 Atlas of American Agric. Part I, Sec. E.

improvements including fencing, water development, reseeding and noxious plant control. However, the prevalent overuse previous to the early 30's, and in many instances since then, resulted in much deterioration of the range resource with its attendant increase of undesirable plants and the reduced effectiveness of plant cover in preventing loss of fertile topsoil. Once started this process is difficult to stop, particularly where the range is in poor condition. In spite of the great amount of time and the many millions spent on range improvements by the various action agencies and by individual livestockmen the problem of range deterioriation generally is enormous and because of its effects on streamflow and soil movement it is certainly not one to be complacent about. For example, the Loveridge-Cliff inspection of national forest ranges in the Southwest in 1945 revealed a discouraging number of grazing allotments in unsatisfactory condition and most of these were still deteriorating. This in spite of marked reductions in grazing use during the period 1920-1944.

A range resource and economic survey comparable to the forest survey is badly needed not only for the Southwest but for all western range lands. Such a survey should assemble and interpret the basic facts relating to the resources of all range lands, regardless of tenure, their present condition, management potentials, suitability to different kinds of ownership, improvement needs and proper coordination of range and farming land use. The survey should be a continuing project to permit periodic re-examination (at least on a sample basis) of range areas in order to determine trends in range condition. Such information would eventually prove invaluable in planning future programs of range land use and conservation. Considerable research in checking existing standards for classifying range condition and developing criteria for range types not now covered would be necessary prior to undertaking a survey of this nature.

In discussing the characteristics and problems of each of the major range areas attention will be focused mainly on the management phases such as what is the present condition and trend in condition of range (at least in the best judgment of the author) within each of the provinces--what we know now and what we need to know for most effective management in the future to bring out improvement of range lands and place this resource on a sound basis wherein all land values are protected. Problems relating to range reseeding and noxious plant control have been covered elsewhere in other problem analyses--principally by Glendening and Parker--and these phases will be touched upon only as required to develop the over all picture of range problems in the Southwest.

NORTHERN DESERT - SAGEBRUSH

Characteristics, scope and land values.--The northern desert shrub or sagebrush range area is confined largely to the region north of the Colorado and Little Colorado rivers (known locally as the Arizona "strip"), and the northwestern part of New Mexico. It comprises an area of about 17.4 million acres (see Table 3) ranging in elevation from 2500 to 7000 feet with an average of about 4000 feet. Precipitation varies from 5 to 14 inches with the bulk of the area receiving 10 inches annually. Most of the land is Federally owned (Navajo and Hopi Indian Reservation). There are no cities of consequence and the population is sparse. The people, both Indians and whites, are dependent for a livelihood primarily on the range--there being but little dry farming and irrigated land. On the Indian reservations population pressure on these meagre agricultural resources is terrific. It is a "hard" country with beautiful and awe inspiring scenery--which offers a marked tourist attraction and a market for Indian rugs and curios. In the vicinity of the Kaibab National Forest the area becomes the winter home of thousands of deer and further west for sheep which winter there and summer further north in Utah. The latter area is isolated by the mighty Colorado river and the people look to the north for trade and social well being.

Vegetation is characterized by big sagebrush (Artemisia tridentata), blackbrush (Coleogyne ramosissima), rabbitbrush (Chrysothammes spp.) with Indian ricegrass (Oryzopsis hymenoides), western wheatgrass (Agropyron smithi), blue grama (Bouteloua gracilis) and sideoats grama (Bouteloua curtipendula). Flood flats and plains are frequently covered with alkali sacaton (Sporobolus airoides). There are extensive areas of black grama (Bouteloua eriopoda) resembling in many respects the semi-desert grasslands of the southern part of the region. Also included in this zone are fairly large areas of pinyon-juniper woodland and in the higher mountains ponderosa pine forests. Vast areas, such as the Painted Desert, are characterized by geologically immature soils--"bad lands" which support little or no vegetation.

Major Problems.--The agricultural possibilities of the northern desert shrub range were at one time viewed with unmixed enthusiasm as recently as 1915. McOmie (Arizona Agricultural Experiment Station), Jacobs (District Engineer U.S.G.S.), and Bartlett (Asst. State Entomologist) ( ) after visiting the Arizona strip observe:

> "House Rock Valley contains about two hundred and ten square miles of land, part decomposed limestone and part decomposed sandstone. These kinds of soils are recognized as the finest of agricultural soils. This land can easily be put under cultivation.
>
> ....at Fredonia there are about one thousand acres under irrigation ....There are about the town a great many acres of good dry farm land....Crops seen growing at Short Creek prove its value.
>
> In all there must be north of the Canyon in Arizona good agricultural land to the extent of well over the three-quarter million mark, perhaps approaching one million acres."

Needless to say, the prevailing low rainfall has prevented the establishment of agriculture on such a scale, in fact there is probably not much more land under cultivation today than in 1915 (with the exception of the limited area around Farmington, New Mexico). A deficiency of farm land plus the overcrowded Indian population on the reservations has resulted in an intense demand for range; with resultant continued overstocking and deterioration of the resource. The remarks of Lord ( ) on the plight of the Navajos are more to the point:

> "By the beginning of the present decade (1930) the tribe (Navajo) had been driven by need to increase flocks until more than 1 million sheep, some 30,000 native cattle, and as many horses were grinding

> the range to pieces. The good grass, dying was replaced by a straggling cover of non-edible and sometimes poisonous plants. Rainfall which used to soak into the range as into a rug or blotter, now dashes off as does rain on a tin roof. Water running rampant cut one small stream, the Oraibi, into a twisting gully 80 miles long, and from 20 to 80 feet deep. Other gullies cutback at the head, devouring new acres."

Estimates of deterioration for the entire sagebrush grass type in the West made by McArdle et al ( ) indicate that the forage on about 84 percent of the area has been severely or extremely depleted and "has been at least materially depleted on nearly all the rest." These workers estimated that in its virgin condition this type of range would support one cow on three acres for a month whereas in 1935 nine acres were required. Some improvement in forage production doubtlessly has occurred since then on limited areas--mainly within those lands administered under the Taylor Grazing Act. For the province as a whole deterioration has doubtlessly continued.

The detailed studies of Thornthwaite et al ( ) on accelerated erosion and its causes were made in the Navajo country in 1942. A few excerpts are noteworthy:

> "Under natural conditions, in the Polacca Wash Drainage and through most of the Southwest, the plant cover protected the soil and retarded the flow of water off the lands. In the valleys, deposition exceeded removal....With acceleration of erosion, short discontinuous gullies became more numerous....Gully cutting is the most obvious and most destructive of the erosive processes at work in the Polacca drainage, but sheet erosion and wind erosion are also reducing the usefulness of the lands. Owing to sheet wash on the mesa surfaces bare rock is now exposed where once was grass-covered soil. On pediment slopes and alluvial fans, sheet wash is gradually removing the most valuable part of the soil cover. Wind erosion is destructive in certain parts of the area and has become of increasing severity within the memory of the native inhabitants. Shifting sands have forced the abandonment of fields and corrals and are now so widespread along the lower Polacca that they obscure the basic structure of pediment, fan, and valley fill. Wind erosion will become still more dominant in this part of the area unless vegetation is planted to anchor the shifting dunes.

Owing to the delicate adjustment of vegetation to climate in the Southwest, a succession of even a few dry years may so impoverish the plant cover that rains of heavy, or even moderate, intensity can initiate a period of accelerated erosion. Climatic records and news reports show that from time to time parts of the region have been visited by storms of exceptional intensity. These are as characteristic of the Southwest as is its semiarid climate.

For all given climatic conditions there is a certain minimum plant cover needed to protect the land against destructive erosion. In arid lands with little or no vegetation and low precipitation there may never be sufficient vegetation to offer protection from the infrequent rains. The dryness of the ground and the lack of well-marked water channels may prevent rapid-run-off, but a permanent inadequacy of cover is characteristic. In semiarid lands the plant cover may be barely adequate to resist the impact of the climatic elements. The margin of safety is slight, hence the amount of vegetation that can safely be grazed is small....

The Polacca drainage is now suffering the results of a grazing economy that was introduced to the Indians of the Southwest about 1540 and has been practiced with little change to the present time. The human and animal population was not heavily concentrated in this part of northeastern Arizona until after the Civil War. It appears to have taken 15 to 25 years for the increased grazing on this land to reduce the vegetal cover to such an extent that changes in erosion became recognizable to the human inhabitants. Serious gullying at most other localities in the Southwest correlates well with expansion of the cattle industry stimulated by the building of the railroads. Acceleration of erosion is reported to have begun in much of the region between 1880 and 1890, and in certain areas probably a decade or two earlier.

In the Polacca drainage, as is general in the Southwest, the lowering of the ground-water level through the cutting of deep gully channels is more significant than the removal of soil by run-off. In most of the semiarid and arid regions the soil profile is imperfectly developed or immature, hence, the loss of a few inches from the ground surface is far less vital than a similar loss would be in a humid land. Water is of greater importance. It is essential that the run-off, instead of draining away immediately to deep gully channels, be kept on the lands. With increased water supply, vegetation can establish a more complete cover. The plants will not only help to hold back run-off by the mechanical obstruction they offer but by transpiration and by promoting infiltration they will diminish the amount of water to be carried away.

Mechanical aids such as diversion dams, distribution ditches, and spreader structures, modernized since the days when they were applied to these areas by the Hopis and other agricultural Indians, can be used to ieep water out of the gullies and spread it on the valley lands, where it can do more good. The major dependence, however, must be placed on a plant cover adequate to protect the soil against the occasional heavy rains."

There is little doubt that erosion rates in large sections of the northern desert range have long been naturally rapid. The Grand Canyon of the Colorado is a monumental example of this natural phenomenon. It will be recalled that Ives ( ) on his visit to the Little Colorado in 1858 noted the chocolate colored water carried in this stream. This stream passes through a particularly arid piece of country where the average annual rainfall is from 6 to 8 inches, which, with the naturally poorly developed soils, supports only a sparse vegetational cover. The effect of such areas on sedimentation should not be overlooked nor discounted as to their magnitude. On the other hand they should not be pointed to or used as an excuse for man-caused accelerated erosion in other sites. In a study of such erosional phenomena Bailey ( ) concludes:

> "The influence of climate on gradational processes is so evident that it is always a possible cause.---The destruction and modification of the plant cover by overgrazing appear to be the dominant cause of the recent epicycle of erosion.---The lack of any change in the gradation of naturally barren areas, such as Bryce Canyon and the Chinle badlands, evidences that there has been no effective change in quantity or rate of rainfall. The sequence of settlement, with its attendant heavy utilization of the vegetation, and the inception of channeling of the valleys, strongly support the conclusion that destruction and modification of the plant cover are major causes of the present epicycle."

Accelerated erosion and range deterioration is of significance in the future welfare and economy of the local people. Furthermore accelerated erosion in the northern desert area is of especial and far reaching import to the urban, industrial, and agricultural life of the irrigated sections of Arizona and Southern California because the silt from these lands is deposited behind the great reservoirs and hydroelectric projects of the Colorado River. These lands contribute but little water and most of the sediment which is inexorably shortening the life of these costly developments.

Major range problems in the northern desert shrub area may be briefly listed as follows:

1. Grazing management: Much information is needed on grazing capacity and criteria for judging condition in the various range types in order to intelligently balance livestock numbers with the forage supply and to devise improved methods of handling livestock adaptable to the Indian way of life.

2. Accelerated erosion: Practical guides and aids in reseeding and noxious range plant control together with improved grazing management practices are needed to improve the plant cover.

3. Wildlife: Improvement in the winter range conditions of the Kaibab deer herd is needed for sustaining and conserving these animals for sportsmen and recreationists. Unless sound wildlife grazing management can be assured, improvement of the range resource will not be possible.

Range research - past and present.—Range research on the problems listed above has been meager and has been confined almost entirely to the Mexican Springs Experimental area, which is largely demonstrational, in the Navajo Reservation initiated by the Soil Conservation Service and now administered by the Indian Service. The results of this work, which demonstrate that these ranges can be maintained, improved, and yield a profitable return through proper management, have been reported by Hubbell and Gardner( ) and Hubbell et al ( ). The results of experimental work in management and reseeding at the Desert Sheep Experimental Range of the Intermountain Forest and Range Experiment Station in Utah is probably applicable to much of the northern desert range area.

Proposed future range research.—In view of the minor importance of the northern desert area as range, any future work in range research that might be undertaken should probably be given low priority. However, if the silt and sediment contributing rates are considered it would seem well worth the money to place at least one man (of P2 or 3 grade) in this area (to be administered through the Fort Valley Work Center) to carry out studies in reseeding, which also implys noxious plant control for big sagebrush and rabbitbrush.

There is need too for a man of similar grade to determine wildlife (deer) relationships with cattle on the Kaibab deer range. However, such work is now underway as a joint undertaking between National Forest Administration with a full time man (P3 grade), and the Arizona State Game Commission with a full time, technically trained man financed with Pittman-Robinson funds.

DESERT SHRUB

Characteristics, Scope and Land Values.--The desert shrub range area comprises nearly 24 million acres; over 10 percent of the entire southwestern region (see Table). It is confined to the Southwestern third of Arizona (see Fig. 7). Precipitation varies from 3 to 12 inches with the bulk of the area receiving about 6 inches. Elevations range from 137 to 3000 feet with most of the area at 1500 feet. Evaporation and summer temperatures are extremely high.

Most of the land is Federally owned being under the jurisdiction of the Indian Service (Papago, Gila and Colorado Indian Reservations), the War Department, the Fish and Wildlife Service, and the Bureau of Land Management. The private lands represent solid holdings of some 600 thousand acres constituting the Salt River, San Carlos, and Yuma irrigation projects. These lands are part and parcel of the heart of Arizona's irrigated agricultural regions. According to Barr ( ) cash income in 1947 from farms and ranches in the State ranked cotton first with 74 million dollars, lettuce and other truck crops second with 40 million dollars, cattle and calves third with 37 million dollars, the latter figure including the many thousands of animals pastured on irrigated lands. The bulk of the irrigated lands are white owned or controlled. Arizona's two largest cities, Phoenix and Tucson, are within the desert range area. Each year this area attracts thousands of health seekers and winter vacationists.

Vegetation is characterized by creosote bush (*Larrea tridentata*) often in pure stands, mesquite (*Prosopis juliflora velutina* and *P. juliflora torreyana*) saltbush (*Atriplex* spp.), paloverde (*Cercidium* spp.) and saguaro (*Carnegia giganta*), cholla cacti (*Opuntia* spp.), catclaw (*Acacia greggii*), ironwood (*Olneya tesota*), burroweed (*Aplopappus tenuisectus*), bursage (*Franseria* spp.), and brittlebush (*Encelia farinosa*). Except for the mesquite and saltbush most of these plants are nearly valueless for grazing. In fact much of the desert shrub range province is of submarginal value for grazing use. As is characteristic of a climate so near to desert the vegetation has always been sparse and inadequate for protecting the soil surface. Grasses consist mainly of Bush muhly (*Muhlenbergia porteri*), big galleta (*Hilaria rigida*), rothrock grama (*Bouteloua rothrockii*), with tobosa (*Hilaria mutica*), alkali sacaton (*Sporobolus airoides*) and Johnson grass (*Sorghum halpense*), in the flood flats. The bulk of the forage is produced from winter-spring annuals, including filaree (Erodium cicutarium), Indianwheat (*Plantago purskii*), six weeks fescue (*Festuca octoflora*), and *Schismus barbatus*, a grass of Mediterranean origin.

Soils on the ridges and hills are shallow and rocky. The extensive plains support soils adaptable for irrigation. The water from the proposed central Arizona project, if and when it materializes, will be used first of all to supplement present water supplies and anything left over may possibly place upwards of some half million additional acres under irrigation.

The desert shrub area is truly one of the great "open spaces" of the west. Aside from the rich, lush, irrigated areas it has but little to offer in the way of land values. It has little or no value as watershed and, furthermore, the sediment from these lands offers no threat to reservoirs which are located in the higher country; much of the land surface is effectively covered with a true desert pavement and storms are few and infrequent. On a regional basis its value for range is extremely low; most of the quarter million cattle and the 70 thousand sheep are supported on irrigated lands. Over half the area is but little used by livestock because of lack of palatable vegetation and sparsity of stock water. In the higher rainfall portions a few ranches operate on a yearlong basis. The most successful operations are those which stock the range only during the more favorable spring seasons. There are occasional years when forage growth is abundant.

Major problems:--According to McArdle et al (   ) about 81 percent of the desert range area is severely depleted. These writers point out further that "on the relatively small accessible grazing area of the type, forage depletion has proceeded so far, and the climatic conditions are so severe, that restoration of the range will be exceedingly difficult and very slow." It is the opinion of the writer that even in its virgin condition, the plant cover in most of this province was of low value for grazing. Notes by Pumpelly (   ) made prior to 1870 indicate that forage in this area was probably always scarce. In the inaccessible or unusable areas where the rainfall is below 6 inches annually, there has probably been but little change in historic times other than the changes wrought by fluctuating weather. In the flood flats and the higher rainfall areas (10-12 inches annually), grazed regularly by livestock, there has undoubtedly been marked deterioration from the original condition through the destruction of most of the perennial grasses such as bush muhly and big galleta. This loss has probably been more than balanced in many areas through the introduction (largely accidental) of winter annuals such as filaree and Schismus. These plants form an effective cover against raindrop splash erosion. The success of these exotic annuals in becoming established does offer considerable hope for reseeding research.

Past range research.--The higher rainfall portion of the desert range area is represented on the Santa Rita Experimental Range, particularly in Pastures 3 and 5. Grazing management research for this type is discussed further in the section on semidesert grassland-shrub range area. Thornber ( ) in the early 1900's made some observations on effect of protection from livestock grazing for eight years on an area of 336 acres in the creosotebush-cacti type near Tucson where the average annual rainfall is nearly 12 inches. Thornber concluded:

> "To sum up briefly, there has been very little change in the vegetation within the small enclosure during the eight years of protection and it seems reasonable to assume that this condition would be true for the most part for the greater portion of greasewood-cactus mesa country in southern Arizona lying at altitudes below 2,600 feet."

This was in contrast to the recovery noted by Thornber within four years on the nearby Carnegie Desert Laboratory grounds (present site of the Southwestern Forest and Range Experiment Station) where there was a "marked increase in the perennial grasses" on the north slopes after grazing had ceased. Shreve and Hinckley (   ) found marked increases in total plant population, mostly in the number of shrubs and grasses increased significantly from a negligible component after 30 years of protection from grazing. After some 40 years of protection these same slopes have probably attained a condition comparable to that of the virgin state—with many species of grasses, characteristic of higher rainfall, being prevalent. However, the vegetation is still sparse and probably represents all that the climate will support. The adjacent flat areas of creosote bush have not markedly improved, especially in respect to the effectiveness of the vegetation in protecting the soil.

Beginning about 1936, reseeding studies were undertaken by the Soil Conservation Service in cooperation with the Southwestern Forest and Range Experiment Station and the University of Arizona in the desert shrub type as represented on the Santa Rita Experimental Range. The results of this work are summarized by Hamilton (   ). The Indian Service has carried on a considerable reseeding program on the Papago Indian Reservation with varying success; the most discouraging being 10,000 acres planted by airplane with pelletized seed in 1946. This work is unpublished.

Proposed future range research.--Because of the relatively low values involved in the desert shrub lands, it would not seem wise to expend too much time and effort in research in this area, particularly on the management phases. However, research work in this province will, of necessity, be undertaken in conjunction with a study of other vegetational types as in a consideration of range sheep management or in cattle management as represented on the Santa Rita Experimental Range. The Station does not now, nor has it in the past engaged in work which related directly to sheep management, although activity of this kind was at one time proposed. In fact, considerable time was spent in the late 1930's for this work to obtain title to the extensive Campbell-Francis sheep holdings in central Arizona which extended through several major range provinces. Whether or not similar opportunity will again occur is doubtful. The sheep industry in Arizona is a decadent one and at low ebb but it will probably have an upswing some time in the future. Information on better management and handling practices and investigation of the possibilities of open grazing under fence should be investigated. A minimum for initiating this work which would cover several range provinces would require the full time services of one P3 man. Cattle management work at the Santa Rita as it pertains to the desert shrub range province should be continued.

There is need for research work in reseeding in the desert shrub area, with particular reference to the higher rainfall sections and the flood flats. Such work, however, should be approached slowly at first in order to explore more fully the needs and the possibilities of reseeding. After all much of the range is sub-marginal and yearlong ranching enterprises are precarious unless supplemented with better range elsewhere or with irrigated pasture. It would require the full time services of a P2 grade for a minimum of three years. Both management and reseeding phases should be headquartered out of the Santa Rita

Work Center.

Some work in noxious plant control is needed, but this relates mostly to the flood control problem on the Salt River and the use of water by the salt cedar (_Tamarix_ spp.), hence it cannot be considered as a range job.

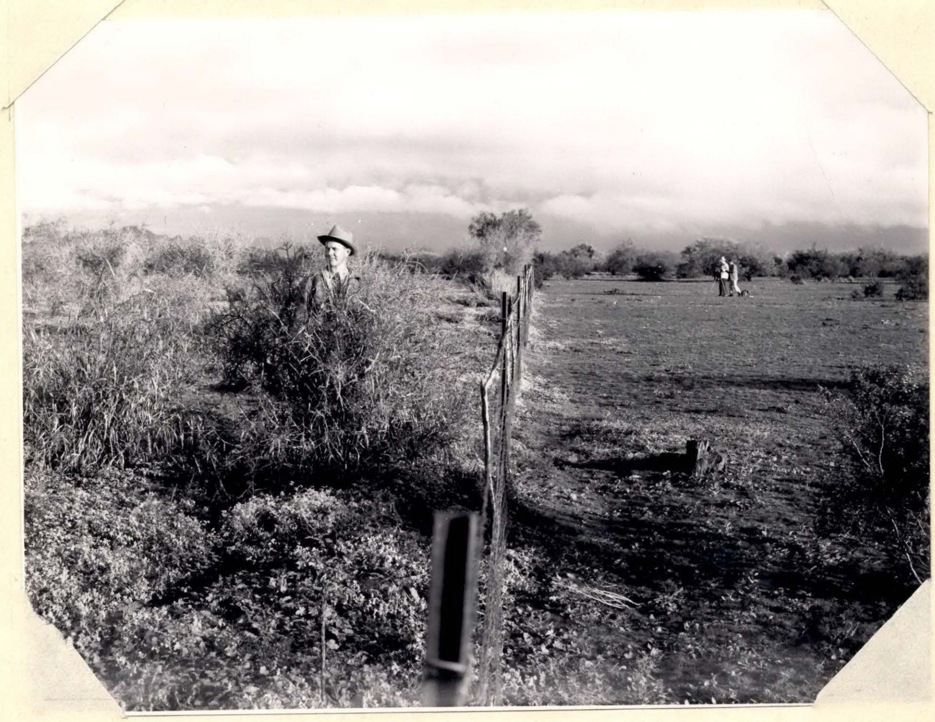


Figure 8.—There is some promise for reseeding in the flood flat areas of the desert shrub range province. Photo shows growth of giant panic grass (Panicum antidotale) near Apache Junction, Arizona (Planting by S.C.S. in 1937 photo taken 1947).

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SEMI-DESERT GRASSLAND-SHRUB

Characteristics, climate, vegetation, soils.—This range province comprises nearly 60 million acres, making up about 26 percent of the total regional area (see Table 4), and is larger than the State of Oklahoma. The semidesert range area is confined largely to western Texas and the southern parts of New Mexico and Arizona. Rainfall varies from 8 to 20 inches per year, but for the most part approximates some 12 inches annually. Wind storm are common and may last for several days at a time. Elevations vary from 3000 to 5000 feet, with an average of about 4000 feet. Some of the mountain peaks included rise abruptly to over 9000 feet. The drought frequency is 2 to 3 years out of 10. However, in most of the area, rainfall is concentrated in the months of July, August, and September. This permits the development of grassland, even with an average yearly rainfall as low as 9 inches, as is found in the Jornada bolson of Southern New Mexico. Growth response to rainfall is rapid during the summer months and 90 percent or more of the volume growth of perennial grasses takes place at this time.

The vegetation is sparse, even in the grassland areas, a reflection of the generally low rainfall. Any disturbance which thins the plant cover, greatly reduces its effectiveness in preventing accelerated erosion. Wind erosion may be severe in this province, particularly so in the southern portions. The semidesert range area is made up of a number of distinct vegetational communities. The most important of these are as follows:

1. Black grama (*Bouteloua eriopoda*) grassland - New Mexico, West Texas, Northern Arizona.

2. Tobosa (Hilaria mutica) or alkali sacaton (Sporobolus airoides) plains and flats subject to flooding. (New Mexico, West Texas, Arizona).

3. Mixed grama grassland (Arizona-West Texas).

4. Mesquite-grassland (Arizona - West Texas).

5. Mesquite sandhills (New Mexico-Western Texas).

6. Creosotebush (Arizona, New Mexico, West Texas).

The distribution, floristic characteristics, and successional stages of these vegetational communities have been described in greater or less detail by Shantz and Zon ( ), Shreve ( ), Clements ( ), Campbell, Bomberger ( ) and Talbot ( ).

The grassland types, particularly the grama communities, are of greatest value for grazing whereas the mesquite sandhills and creosotebush types are characteristically low in forage values. The grass forage throughout the semidesert range province, as is generally true elsewhere in the Southwest, becomes deficient for animal health in protein and particularly phosphorus, at least during the winter months. These deficiencies and the resultant problems in animal nutrition are described by Watkins ( ), Lantow ( ), Knox and Watkins ( ), and Parker ( ).

Soils within the semidesert range province are typical of those which develop under a semiarid climate. Each mountain peak or foothill appears to be half buried in its own debris. The mesa and upland soils of the black grama type are light, shallow (averaging 12 inches or less in depth), and underlain with caliche. The mixed grama and mesquite-grassland types which bear many similarities to the short grass community occur on soils with well developed profiles. The shrub types--creosotebush-- are characterized by poor shallow soils underlain with caliche--although these vegetational communities often occupy valley fills and deep soils of alluvial origin. Erosivity of these soils varies greatly with geologic origin, character of plant cover and range condition.

Land values.--The semidesert-grassland-shrub range localities are second only to the short grass range areas from the standpoint of importance to the livestock industry. Within this province are over a million head of cattle (30.3 percent of the region) and nearly 600 thousand sheep (8.6 percent) (See Table 4). Lands subject to irrigation are fully developed, notably along the Rio Grande and Pecos rivers in New Mexico and the Gila in Arizona. These lands form a vital part of the agriculture of the two states. Unirrigated lands are too arid for successful dry farming. The watershed values of the semidesert range province are low but much sediment has its origin therein. This sediment is filling the reservoirs and aggradating stream channels, as may be observed along the middle Rio Grande. Wildlife values are low and are confined mostly to a few mule deer, to a few bands of antelope, and to upland game birds such as gambel quail. Timber values are nil.

Land status in the semidesert range province in Arizona and New Mexico is predominantly federal ownership, mostly under the jurisdiction of the Bureau of Land Management. Solid blocks of private land occur in southeastern Arizona.

Major problems.--Deterioration in the semidesert range province has been marked since the introduction of domestic livestock. According to McArdle et al (   ) deterioration in grasslands in 1935 covered 90 percent of the type and in the shrub areas about 81 percent "is severely or extremely depleted," and in some areas has "proceeded so far.... that

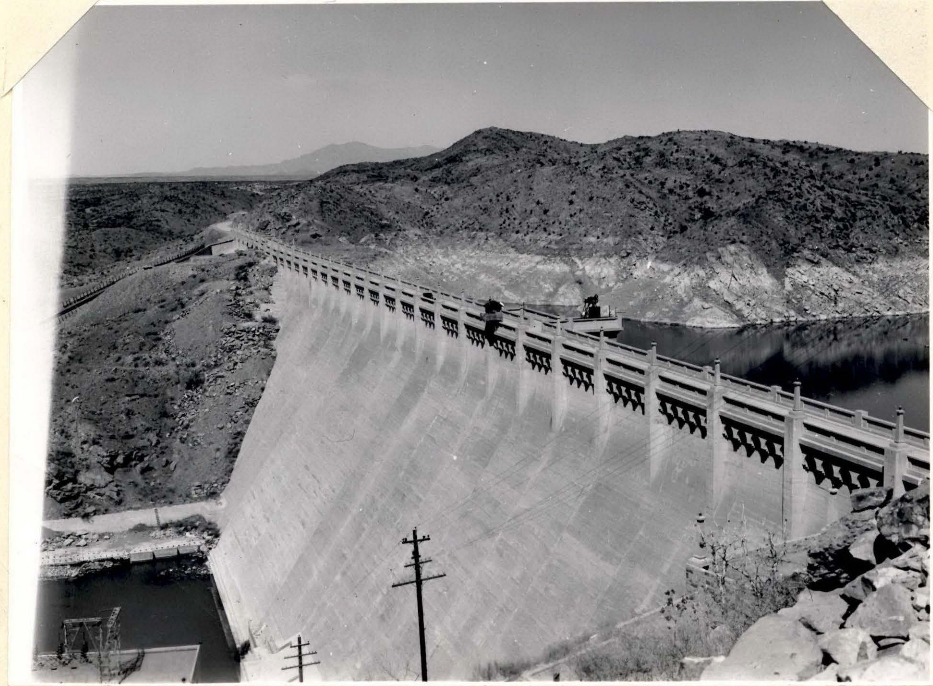

Figure 9.--Reservoirs such as this (Elephant Butte, New Mexico) store the life giving waters of irrigated agriculture.

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restoration of the range will be exceedingly difficult and very slow."

In the grassland types, changes that have occurred and are still taking place have resulted in lowered forage production, thinning of the forage cover, and the replacement of desirable perennial forage grasses with low value plants such as snakeweed, burroweed, and mesquite. That these changes are continuing apace is well documented by the data collected from numerous experimental plots both grazed and ungrazed which are scattered throughout the region. The most indisputable evidence of these changes, at least in the eyes of the layman, are photographs repeated periodically. An example of these is presented in fig. 9. Accelerated erosion rates have generally accompanied these changes. McArdle et al ( ) estimates that grazing capacity has been lowered from 30 to 87 percent from its virgin condition. Darrow ( ) in a careful appraisal of the forage resources of Cochise county, Arizona, in 1944 reported a need for balancing livestock numbers against forage sources on rangelands and that the present forage productivity is "considerably below potential capacity" because of past over-utilization by livestock.

In the creosotebush types, the herbaceous forage cover has largely disappeared. These changes on both grass and shrub types have in large part been due to excessive grazing use continued year after year, together with the periodic occurrence of extreme droughts. Livestock numbers have on the whole been out of balance with range forage production since the late eighties. This upset in balance was climaxed by the all time high in livestock population of the early 1920's which had disastrous effects on the range resource.

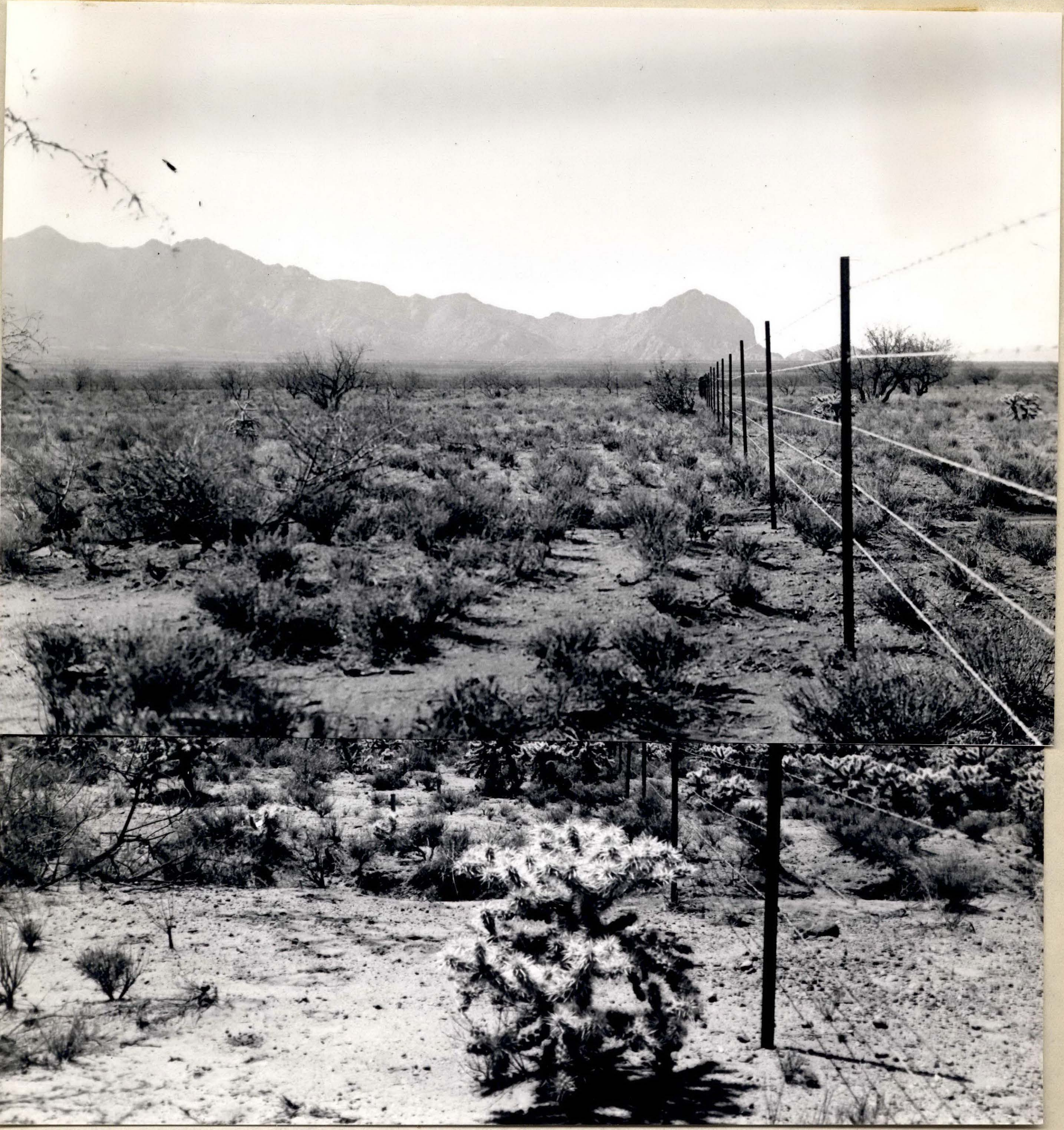

Figure10.--Changes in range vegetation may be rapid and spectacular. In this instance an invasion of cholla cacti (Opuntia fulgida) within a decade has changed the aspect. Reduced forage values and accelerated erosion rates generally accompany such changes. The area shown to the left of the fence has been ungrazed by livestock since 1936 but the enclosure is small, open to rodent grazing and being on a slope is influenced by the outside grazed area above. Area to right of fence open to yearlong grazing use. Top photo taken in 1936--lower photo repeat from same point at Enclosure #37 Santa Rita Experimental Range.

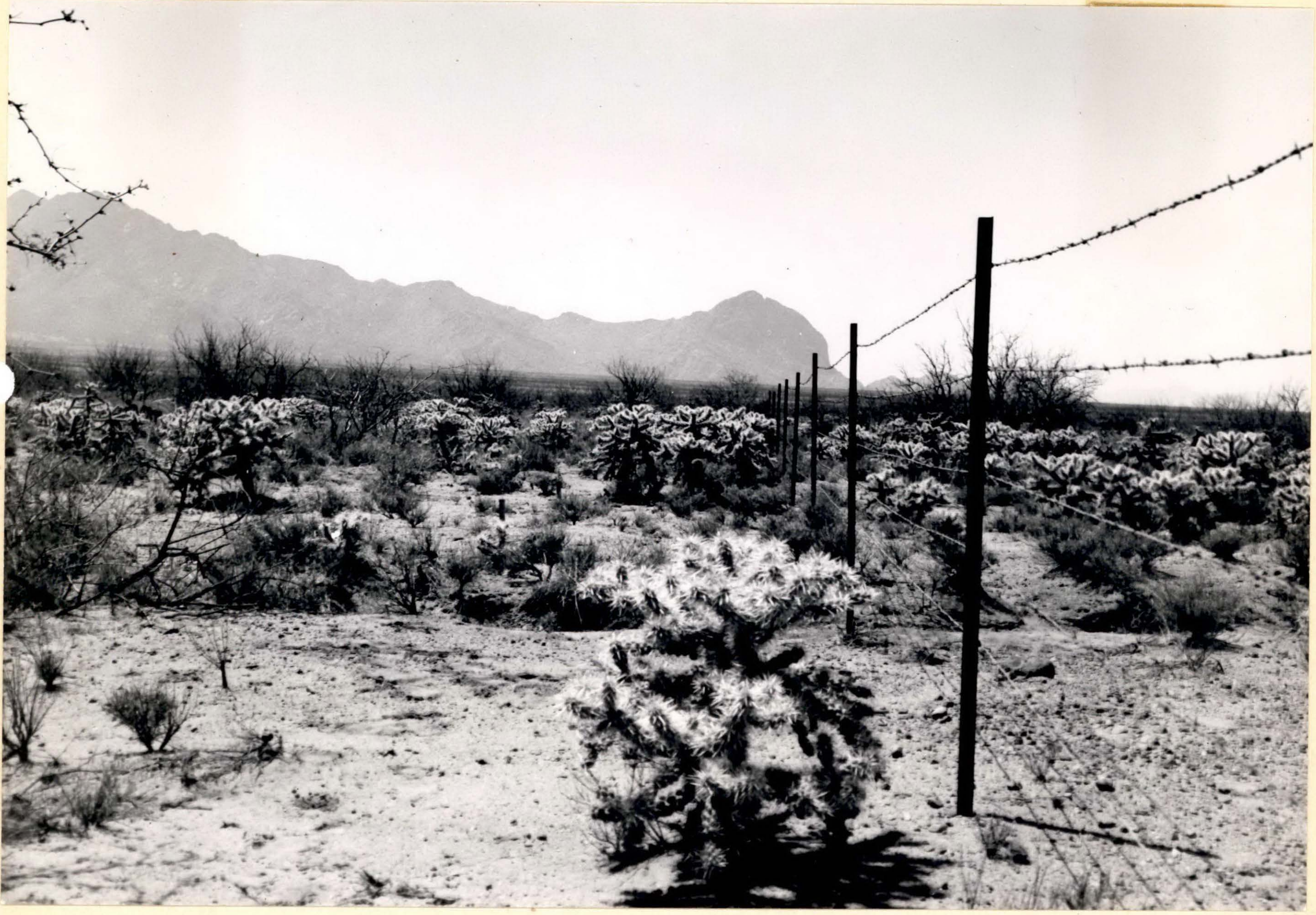

Figure10.--Changes in range vegetation may be rapid and spectacular. In this instance an invasion of cholla cacti (Opuntia fulgida) within a decade has changed the aspect. Reduced forage values and accelerated erosion rates generally accompany such changes. The area shown to the left of the fence has been ungrazed by livestock since 1936 but the enclosure is small, open to rodent grazing and being on a slope is influenced by the outside grazed area above. Area to right of fence open to yearlong grazing use. Top photo taken in 1936--lower photo repeat from same point at Enclosure #37 Santa Rita Experimental Range.

1936 - RR Humphrey.

Left ungrazed - 200' x 200' enclosure #2

Pasture 12A

1948 – M.J.C.

Copy unsigned – Enclosure #37.

Part 12A –

Other factors, including dry farming and the harvesting of grass for military establishments in the 1870's, have also had an important bearing in bringing about this deterioration. Barnes ( ) reported that he saw hundreds of tons of bush muhly (Muhlenbergia porteri) harvested by hoes and sold at Camp Thomas on the Gila and Forts Bowie and Grant in southern Arizona in 1879 and 1880. The climate of the region has been such as to encourage the yearlong grazing of livestock on the same range area. On most ranges, permanent water is scarce and expensive to develop. This has resulted in concentration of grazing use around the stock watering places and ever widening circles of deterioration as the cattle travel further afield. Continued yearlong grazing use, without periodic rest during the spring and summer growth season, has had a debilitating effect on grass vigor. Then too, severe droughts have greatly reduced the plant cover. It has been the observation of the author that rest from grazing use during anytime of the year may be highly beneficial to range vegetation. This is particularly true with light sandy soils such as are characteristic of black grama grasslands. Rainfall, even though it may be from a light shower, crusts the soil surface and reduces movement of soil by wind. Rest during the spring months, when moisture is limited, permits a buildup of carbohydrate reserves. With no grazing use during the summer growth season the range vegetation naturally recovers through increased plant vigor and because seedlings or other reproductive means are undisturbed by trampling until firmly established. Under yearlong grazing use, normal recovery following drought is hindered even under moderate stocking. Deterioration in range condition is difficult to recognize because changes in the plant cover and soil conditions often take place slowly over a period of many years. Standards for judging range condition have been developed for only

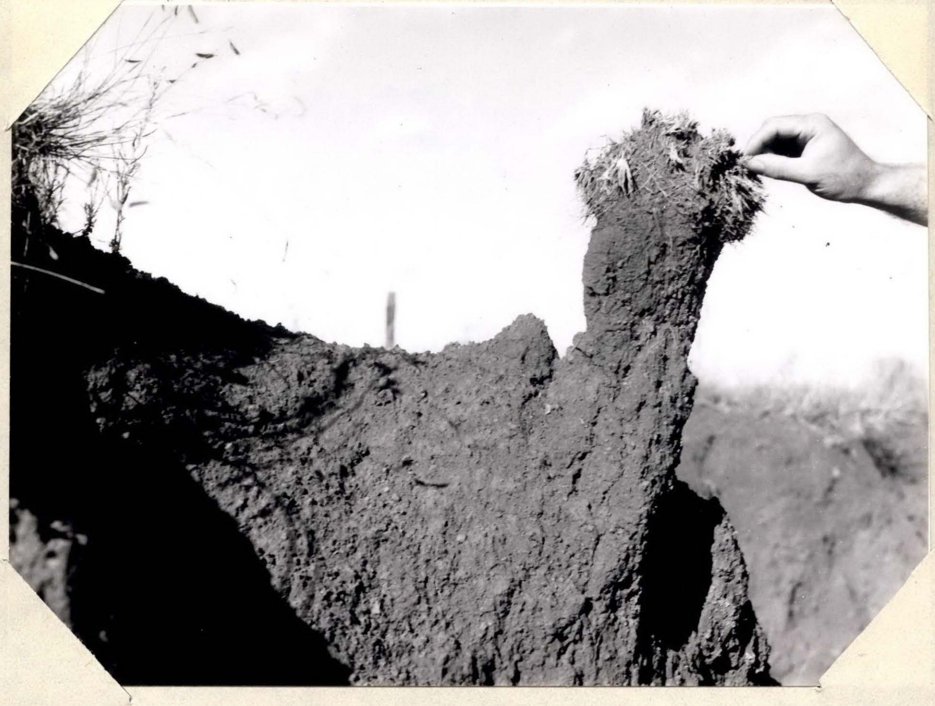

Figure 11.--Erosion rates have accelerated generally throughout the Southwest in all range provinces.

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a few range types and information on criteria for appraising trend is largely lacking. Criteria for judging both condition and trend are needed for effective management. Both condition and trend are largely determined by degree of grazing use. Proper use standards for the principal forage species have been developed but need critical re-checking as well as intensive fundamental investigation. This is true for all of the range types in the Southwest.

Drought, which occurs from one to three years out of every ten, constitutes an ever recurring problem in livestock management. Much work has been done on avoiding the impacts of drought at both the Jornada and Santa Rita Experimental Ranges but further study is needed, particularly on the character of herd make up, the effects of supplemental feeding on both range and livestock, and the management measures necessary following a drought.

In the semidesert range province, as elsewhere in the Southwest, proper distribution of livestock often makes the difference between good and poor management. Riding, fencing, water-development and salting away from water are the usual tools for achieving proper distribution. Stockmen recognize this but are often loath, because of the expense or extra labor involved, to adopt adequate measures for proper distribution of animals. In the case of salting away from water, which is recommended by National Forest Administration, they question its value from the standpoint of animal health and even range productivity. Some research and demonstrations have been carried out but the results have been largely of a gross observational nature. A carefully controlled experiment is needed comparing the effects of salting both at and away from water in terms of the effects on range and cattle as well as the costs and returns.

The influx of low value native plants has likewise resulted in reduced forage yields and accompanying decline in livestock production. Plants such as mesquite, snakeweed and burroweed contribute little or nothing in the way of forage and yet require large amounts of moisture which would otherwise be available for the production of forage. Tremendous acreages are involved in these invasions and thickening up of natural stands. For example, in Southern Arizona a survey in 1937 by Upson, Cribbs and Stanley ( ) indicates that mesquite constitutes a problem on some 8 million acres out of the 12.8 million acres included in the survey. Shrub control problems relating specifically to snakeweed, burroweed, and mesquite, are described in detail by Parker ( ) ( ) ( ) and Glendening ( ).

Unsatisfactory range condition on much of the semidesert grassland types can be corrected with improved methods of range management, including the proper adjustment of livestock numbers. One answer to range conservation often lies in the application of noxious plant control methods; accompanied in some cases with artificial reseeding and at all times with proper range management. Many areas, particularly bottom lands and other areas of livestock concentration, are in such poor condition that reseeding from natural means is too slow for practical results. In these instances artificial revegetation is necessary. The problem of reseeding has been covered by Glendening and Parker ( ). In some situations, water spreading or water retention structures may appear to be a practical means of increasing forage production, but according to Valentine ( ), further research is needed. Range rodents and rabbits constitute a major problem

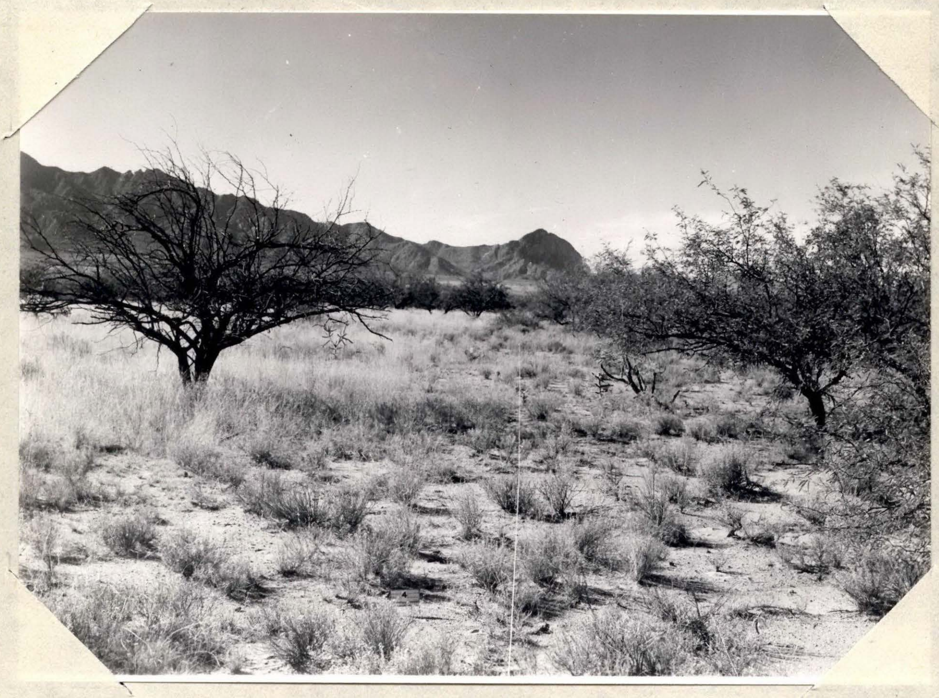

Figure 12.--The influx of low value plants such as mesquite into formerly productive grasslands is a major range problem in the Southwest. Noxious plant control accompanied by conservative grazing use offers real hope for range improvement. Area to left mesquite eliminated (in 1940 photo 1946), check area to right. Santa Rita Experimental range.

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in range improvement throughout the semidesert range province. Once a range area has become in a deteriorated condition the rodent factor alone may prevent recovery within a reasonable length of time as reported by Parker ( ). The degree of abundance of jackrabbits in the semidesert range areas appears to be closely correlated with range condition according to unpublished material prepared by Albert Trowbridge of the Fish and Wildlife Service, formerly headquartered at the Santa Rita. The presence or absence of certain rodent species likewise appears to be associated with range condition. (Unpublished manuscripts by Hudson Reynolds, formerly with the University of Arizona). These leads should be followed and intensively explored not only because of the effects that jackrabbits and rodents may have on the range resource but also for far reaching implications from a public health viewpoint. Native range rodents are now known to be carriers of bubonic plague.

Studies of range soils and the effect of their fertility on forage production is as yet a totally unexplored field of endeavor. The information revealed by critical study would undoubtedly yield information especially helpful in grazing management and reseeding. Some of the problems on which studies might be immediately focused are: How does grazing use affect soil fertility? What elements are deficient? (Phosphorus and nitrogen, for example, are known to be deficient in many southwestern soils). Will application of fertilizers to range soils increase forage production? If it will, how long will the effect last and could this be done on a practical basis? For example: Would application of fertilizers in spots of an acre or so in size assist in livestock distribution? What criteria can be set up on soils to enable range administrators to recognize the productiveness of a site? How is soil fertility correlated with range condition? What are normal rates of litter formation and oxidation?

Research on range problems in the semidesert province has been carried on with varying intensity during many years at both the Jornada and Santa Rita Experimental Ranges. Although these two experimental ranges are both within the semidesert province there are essential differences and similarities which will be discussed in detail later. Range research that has been carried on since time of establishment and that proposed for the future at the Santa Rita and Jornada Experimental Ranges is outlined in the following sections:

Range Research at the Santa Rita Experimental Range

Objectives in establishment.--The Santa Rita is the oldest experimental range in the United States. As reported by Griffiths (177) 31,488 acres of range were set aside and fenced against livestock grazing use in June 1903, in order to facilitate the study of range problems by the Bureau of Plant Industry. According to Wooton (367)"the problems which presented themselves" for solution were as follows:

> "(1) To demonstrate that under proper treatment run-down and over-stocked ranges will recover, a statement of fact that was very much doubted by stockmen when the experiments were begun.
> (2) To ascertain how long a time is necessary to get appreciable and complete recovery, and what methods of management will produce such results.
> (3) To carry on reseeding and introduction experiments in the hope of increasing the total quantity of feed.
> (4) To measure as accurately as possible the carrying capacity of a known representative area."

In 1915, with the assumption of responsibility for all western range research by the Department of Agriculture, the Forest Service, Branch of Research, was designated as administrator of both the Santa Rita and the

Jornada Experimental Ranges. Cooperative agreements were made with four stockmen to furnish livestock for grazing the entire Santa Rita range in accordance with range management plans developed by representatives of the Secretary of Agriculture. This was in accordance with the recommendations for future investigations as planned by the Bureau of Plant Industry. Wooton ( ) stated:

> "....it would seem wise....to determine just what the carrying capacity of this area is, by grazing off the forage crop with a definite number of animals that are kept on it all the time, this number to be based upon estimates already obtained from quadrat measurements and hay-cutting records."

Research work undertaken by the Forest Service was divided into two main categories according to Hensel ( ).

> "first, that part dealing with bringing and keeping the range in a maximum state of productivity. This is called 'Range Management' and is built around Natural Revegetation and its ramifications. The second is 'Handling Stock' and deals with stock only" (Costs and returns, herd improvements, percent calf crop, death losses) "and is concerned chiefly with better and more economical management of the stock, keeping in mind the requirements of the range."

These two broad study projects have been continued without interruption for more than 30 years--with the areas used by each cooperating stockman (now three) serving as practical cattle ranch demonstrations of proper management.

Specific objectives as set forth in the 1939 "agreements for conducting grazing experiments" are in accord and similar in wording with the original purposes set forth in 1915 for undertaking research at the Santa Rita Experimental Range. These are as follows:

> "(A) A plan of range management which will minimize or eliminate the heavy loss of livestock due to periodic prolonged droughts.

(B) System of utilization consistent with clause (A) hereof and based upon the growth requirements of the principal forage plants, which will maintain maximum range productivity and build up depleted range areas.

(C) The advantages of controlling both range and cattle under fence, in maintaining a good grade of cattle and increasing the percentage calf crop.

(D) The grazing capacity of the native range lands when under control.

(E) The amount of salt necessary to satisfy the cattle at different seasons of the year and on different types of forage and the number, character, and distribution of salting places to secure best use of the range.

(F) The loss of animals from all causes under controlled range conditions.

(G) The cost of handling cattle under fenced control over a period of years.

(H) The possibilities of improving the range forage by introduction of new plants, seeding, planting, conservation of run-off, etc.

(I) The number and distribution of livestock watering places necessary to secure proper use of range by cattle.

(J) The advisability of holding heifers which are to be used for breeding purposes away from bulls until the heifers are approximately twenty (20) months old.

(K) The advantages of using supplemental feed to keep the cattle in good breeding condition and to prevent losses from starvation.

(L) Such other problems as may arise, and in the opinion of the party of the second part, justify experimental study during the period covered by this Agreement."

The cooperative agreements on both the Santa Rita and Jornada have, since 1915, served as a statement of objectives. In a letter designated G-Studies SUPERVISION Santa Rita to R. L. Hensel, dated February 7, 1916 and signed by James T. Jardine, Inspector of Grazing, In Charge of Grazing Studies, it is stated specifically: "If you (Hensel) will read these agreements carefully you will get a good idea of what we are trying to do down there." In the same letter, Jardine states that "the work to be carried on--(at the Santa Rita) is pretty well in mind and follows rather definitely the plan in effect for the Jornada." Objectives as set forth in the cooperative agreements at both the Jornada and Santa Rita are currently closely parallel.

Differences and similarities between the Santa Rita and Jornada.-- Range research of the Southwestern Forest and Range Experiment Station, since 1915, has been centered largely at the Santa Rita and Jornada Experimental ranges. Both of these experimental ranges are located in the heart of the semidesert range province. The question naturally arises, isn't there duplication of effort? On the face of it, it would seem so, for both areas have been maintained as practical cattle ranch demonstrations of adequate range and good livestock management. On the other hand there are essential differences between the two areas with respect to vegetation, soils, climate and the range problems worthy of attention. These marked and important variations are sufficiently great to warrant the maintenance of range research work at both experimental areas.

Each of these two experimental ranges are representative of a wide scope of country (see Fig.) and each contain certain range forage types characteristic of different types within the semidesert range province. In fact all of the more important vegetational communities making up the semidesert range province occur in greater or less degree on the two experimental ranges as follows:

Santa Rita	Jornada
Mixed grama grassland	Black grama grassland
Mesquite-grassland	Tobosa grass
Creosote bush	Mesquite sandhills
	Creosote-tarbush

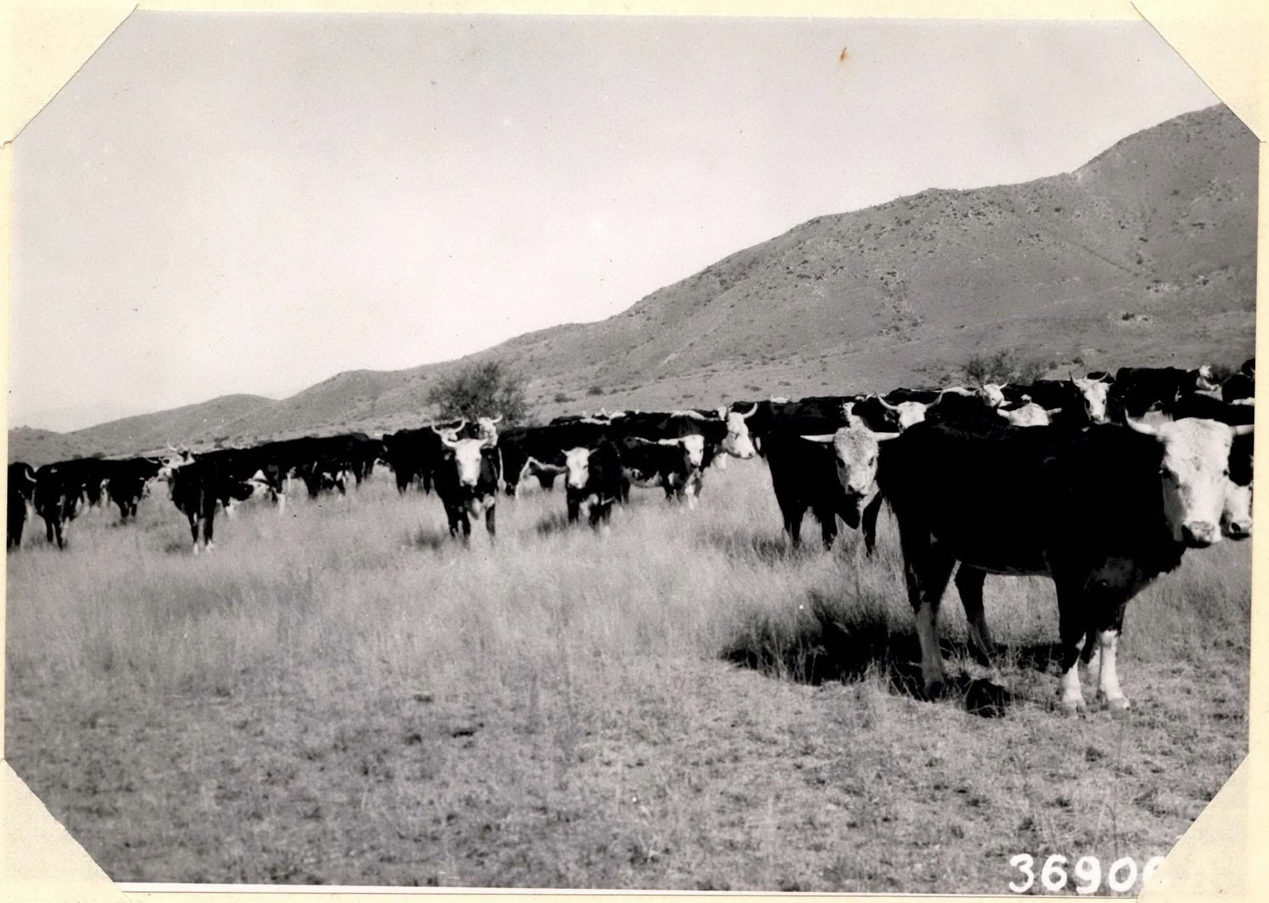


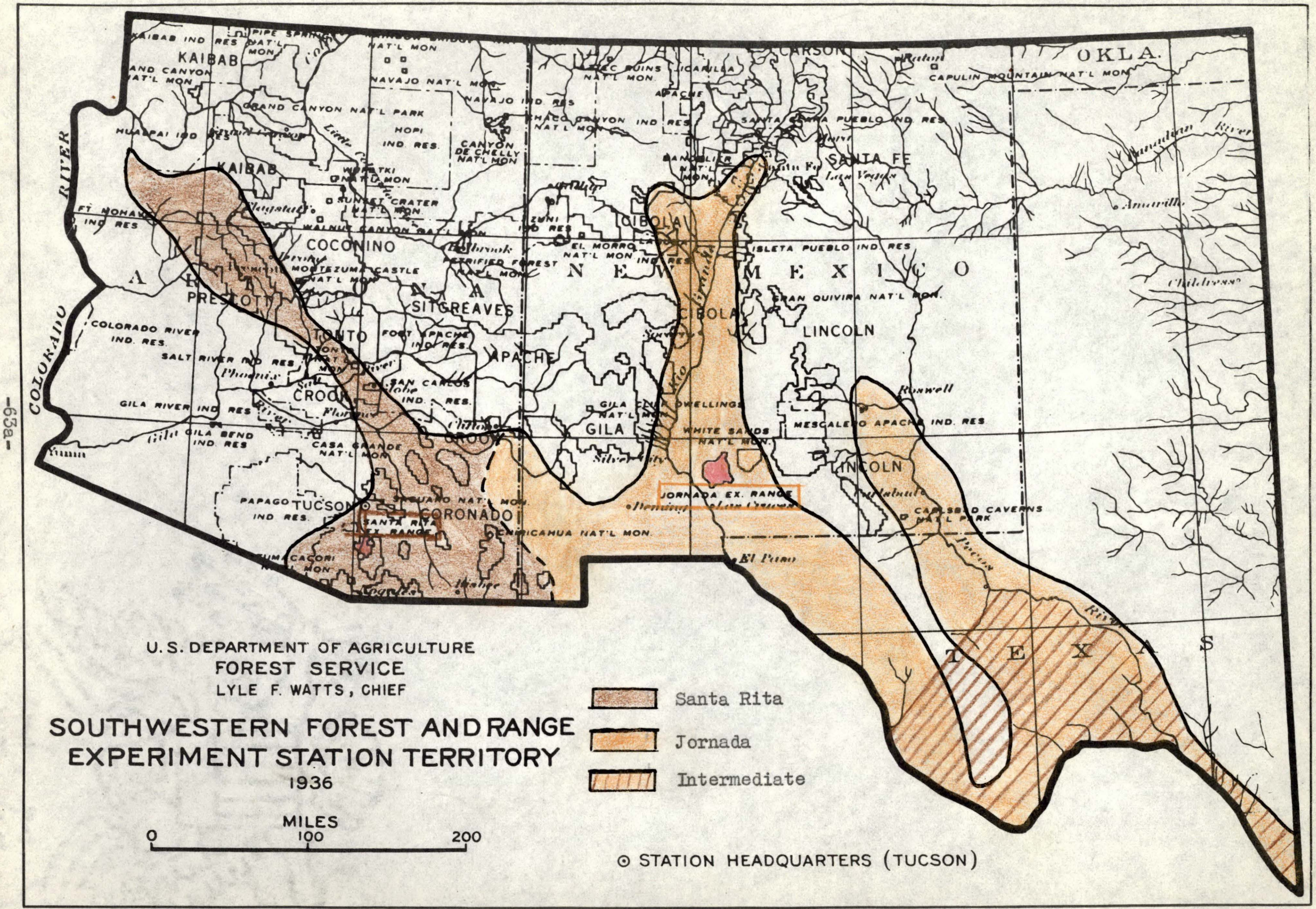
Figure 13.--Condition of range and livestock on the northern portion of the Santa Rita Experimental Range about the fall of 1916.

Within the semidesert range province the Santa Rita may be considered to be representative of 16.5 million acres in Southern Arizona and the Jornada 43.4 million acres in New Mexico and West Texas. There is some overlap in similarity of vegetation and problems peculiar to the plant cover but curiously enough this overlap is not so much on the divisional boundary near the Arizona-New Mexico State line as it is in the big bend country of Texas.

There is a definite basis for the separation of the semidesert range province into two sub-areas, the "Jornada" and the "Santa Rita". This separation is partially based upon the variations in vegetation and soils. For example, differences in the creosotebush community due to the presence or absence of bursage (*Franseria* spp.), tarbush (*Flourensia cernua*) and paloverde (*Cercidium*) are so marked that Clements ( ) recognizes two distinct plant associations.

In the grassland types, the recognized basis for division is the distribution of slender grama (*Bouteloua filiformis*), spruce top grama (*B. chondrosioides*), rothrock grama (*B. rothrocki*), burroweed (*Aplopappus tenuisectus*) and velvet mesquite (*Prosopis juliflora* var *velutina*), all of which are confined largely to southern Arizona.

Soils on the Santa Rita are mostly deep sandy, gravelly loams and clays derived from the outwash of the adjacent Santa Rita mountains. Subsoils are calcareous but caliche formation is rare. These soils are subject to fairly rapid sheet erosion mostly from water, whenever the plant cover is disturbed. Because of the gradual but positive sloping and rolling topography any changes in the character of the vegetation are immediately reflected in erosion rates. Youngs et al ( ), made an


U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
LYLE F. WATTS, CHIEF
SOUTHWESTERN FOREST AND RANGE EXPERIMENT STATION TERRITORY
1936
MILES
0
100
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Santa Rita
Jornada
Intermediate
⊙ STATION HEADQUARTERS (TUCSON)
OKLA.
N E W M E X I C O
T E X A S
A R I Z O N A
COLORADO RIVER
KAIBAB
KAIBAB IND RES
PIPE SPRING NAT'L MON
GRAND CANYON NAT'L MON
GRAND CANYON NAT'L PARK
NAVAJO NAT'L MON
NAVAJO IND RES
HOPI IND. RES.
CANYON DE CHELLY NAT'L MON
HUALPAI IND RES
WUPATKI NAT'L MON
SUNSET CRATER NAT'L MON
WALNUT CANYON NAT'L MON
FT MOHAVE IND RES
COCONINO
MONTEZUMA CASTLE NAT'L MON
PETRIFIED FOREST NAT'L MON
PRESCOTT
SITGREAVES
TONTO
FORT APACHE IND. RES.
APACHE
COLORADO RIVER IND. RES.
SALT RIVER IND RES
SAN CARLOS IND. RES.
CROOK
GILA RIVER IND RES
GILA BEND IND RES
CASA GRANDE NAT'L MON
PAPAGO IND. RES.
TUCSON
SAGUARO NAT'L MON.
CORONADO
SANTA RITA EX. RANGE
TUMACACORI NAT'L MON.
CHIRICAHUA NAT'L MON.
CARSON
AZTEC RUINS NAT'L MON.
JICARILLA
APACHE
CHACO CANYON IND RES
SANTA CLARA PUEBLO IND. RES
BANDELIER NAT'L MON.
SANTA FE
CAPULIN MOUNTAIN NAT'L MON
ZUNI IND RES
EL MORRO NAT'L MON
CIBOLA
ISLETA PUEBLO IND RES
GRAN QUIVIRA NAT'L MON.
LINCOLN
GILA CLIFF DWELLINGS
GILA
WHITE SANDS NAT'L MON.
MESCALERO APACHE IND. RES
JORNADA EX. RANGE
CARLSBAD CAVERNS NAT'L PARK
Flagstaff
Phoenix
Holbrook
Yuma
Silver City
Deming
Las Cruces
El Paso
Santa Fe
Las Vegas
Raton
Roswell
Amarillo
Childress
Rio Grande
Pecos River
Canadian River

Figure 14. Areas within semidesert range province as represented by Santa Rita and Jornada Experiment Ranges.

intensive soil survey of the Santa Rita area and reported their findings in 1936.

On the other hand soils of the Jornada are generally light, sandy loams, shallow in depth and underlain with caliche; except on the outwash alluvium from the San Andreas mountains—which are mostly lithosols of low fertility covered with creosotebush. The dry lake bottoms are characterized by heavy clays with tobosa, alkali sacaton and burrograss. Disturbance of the plant cover takes place wherever wind erosion occurs (and this is often severe),especially in the shallow, sandy mesa soils.

There is also considerable difference in climate. Annual precipitation on the Santa Rita varies from about 10 inches to 18 inches increasing with elevation—the bulk of the area receives about 14 inches. There are two rainfall peaks during the year—a summer and a winter rainy period. Temperature and evaporation are extremely high during the summer. Precipitation on most of the Jornada averages between 8 and 9 inches with the bulk of the moisture coming in the summer months of July, August and September. Although evaporation and temperatures are high in these months an inch of precipitation probably goes farther than on the Santa Rita, at least on the sandy soils where there is little or no run off. However, droughts are apt to be more pronounced and prolonged on the Jornada than on the Santa Rita.

Because of the differences in vegetation, soils and climate the problems in range management and improvement are also varied. On the Santa Rita the problem of determining grazing capacity has been greatly complicated by the invasion and increase in abundance of low value plants such as velvet mesquite, burroweed and cholla cacti. Similar events have taken place on the Jornada with the invasion of honey mesquite (Prosopis juliflora var torreyana) and snakeweed. But the invasion of mesquite on the Jornada has not been so rapid and widespread and, in the case of snakeweed, proper management and stocking can prevent it becoming a serious problem.

Grazing management on the Jornada is conducive to seasonal grazing use because mature tobosa and alkali sacaton are of little value for forage, whereas black grama is palatable at any time of the year and is logically reserved for winter use. The types of forage on the Santa Rita have encouraged yearlong grazing use. The mesquite on the Santa Rita is of the tree habit and does produce forage that is readily eaten by cattle and does help alleviate the problem of maintaining animals during severe drought. On the other hand mesquite on the Jornada is the many stemmed, dune-forming type and the leafage is practically valueless for forage. Mesquite in either area, once it becomes established, requires drastic measures for elimination and is not greatly affected by moderation in grazing use. This is likewise true of burroweed and cholla cactus (which do not occur on the Jornada) both of which constitute major noxious range plant problems in southern Arizona.

The two experimental ranges are situated differently with respect to proximity to national forests. The Santa Rita is adjacent to a national forest (Coronado) and the cooperators are permittees. Hence the results of the grazing management studies are more directly applicable to, and usable by national forest administration. (However the livestock operations, on the experimental range and the forest, in so far as possible are kept strictly separate).

The Jornada is far removed from any national forest and because of this the results have not been readily acceptable by national forest administration even though certain of the principles involved are directly applicable.

The final difference, and one of the most significant from the standpoint of grazing management and handling of livestock, has been and still is the stocking policy. The Santa Rita stocking policy since 1915 is based on stocking the pastures (mostly yearlong), with a more or or less rigid number of breeding cows, forming a high percentage of the total stocking which is fixed at an estimated rate to determine grazing capacity. The bulk of the calves are sold in the fall at marketing time. The Jornada operation is more flexible. Here, breeding the cow ratio to total stocking has been kept purposely low since 1938. Calves are held over as short yearlings in the good years and marketed in the fall in the lean years of forage production.

Past results and pertinent findings.--Progress of range research undertaken by the Bureau of Plant Industry, during the period 1903 to 1915, was reported periodically by Griffiths ( ), ( ), ( ), and major findings were summarized by Wooton ( ). In reviewing this material it should be kept in mind that the major objectives were to study recovery of the vegetation on the Santa Rita following protection from domestic livestock, and to determine grazing capacity. In this respect Wooton's ( ) conclusions are pertinent:

> "Some definite answers are now available as to the time necessary for recovery under different conditions. Three years of complete protection gave about three-fourths of complete recovery for the area where crowfoot grama is the dominant grass, at levels of about 3,500 to 4,000 feet, where an annual rainfall of 15 to 18 inches occurs. One

> inclosed pasture of this type having an area of 794 acres, which has been stocked with horses and burros at the average rate of about 11 head per section, recovered somewhat more slowly than the completely protected area beside it and at the same level, but after 11 years protection is now not appreciably different in carrying capacity from the completely protected area, a condition which has obtained on this pasture for the last two or three years. This would indicate that this pasture recovered under light stocking in about double the time required for the completely protected area. Areas at higher levels might be expected to do at least as well if not better under similar treatment."

Wooton's statement on recovery, reported in 1916, would seem to be in error when one considers the earlier remarks of Griffiths ( ) on the same area with respect to the encroachment of burroweed and mesquite. Griffiths' statement follows:

> "There are really but two weeds in the inclosure, but they are both somewhat serious. One is one of the rayless golden-rods (Isocoma coronopifolia)....not distantly related to the sheep weeds and snake weeds of New Mexico, Texas, and northern Arizona. Here this plant has spread upward from the river bottom and now occupies the rocky ridges and mesas between the grassy section and the more level desert lands below--
>
> Remedies which are effective and at the same time economically applied in the control of the variety of rayless golden-rod mentioned have not been perfected as yet. Burning in the dry season in summer will kill some species of the group. In other words, if there is sufficient herbage upon the ground to burn during the vegetative condition of these plants they will be killed by burning the land over, but burning during the winter season, when they are dormant, will not kill them.
>
> In the region under consideration the golden-rod referred to has increased mainly below the grassy area, such increase having taken place but partially during the time that the area has been under protection....How far it will increase in the perennial-grass area and how its encroachments within and without the fence will compare can not yet be satisfactorily judged. It must be remembered that it takes very much longer to secure positive results in matters of this kind in this region of scanty rainfall than in more favored localities. There are indications that the plant has about reached the limit of its growth here.

Much has been written about the rapid spread of the mesquite (Prosopis glandulosa) and other shrubby vegetation in Texas since the advent of flocks and herds, but the development of this class of plants is so much slower on the inclosed area referred to in this paper that it appears to have been in a large measure overlooked. It is, however, taking place just as surely as in Texas; the only difference is that the growth is much less than half as rapid.

The year previous to the inclosure of the large field a small crop of hay was cut over the best portion of its present area. This, however, was far from any water. Acres were harvested where there was no impediment to the mower. At the present time, six years later, there is not an acre in the whold field where there are no shrubs to interfere with the machine. They are still small, half an inch to an inch in diameter at the base, but large enough to stop a mower. They have made a very perceptible increase within the writer's acquaintance with the area. The prediction is ventured that the time is coming when these foothill grassy areas, which now have only an occasional small shrub, will be as shrubby as the deserts and lower foothills below them, if not more so.

Some of these shrubs do, of course, furnish some feed, but here, as elsewhere,their growth will be largely at the expense of grasses. For a long time the lower foothills, arroyos, and general desert mesas have been shrubby, and the gently sloping tables between the arroyos and the upper foothills are slowly becoming so.

It will doubtless be impossible to depict all the agencies that are bringing about these changes. It is quite certain that the operations here of the Bureau of Plant Industry have had no influence, for the shrubbery has thickened up on the outside of the enclosure, where the grazing has been very heavy, apparently as much as on the inside. The probability is that neither protection nor heavy grazing has much to do with the increase of shrubs here, but that it is primarily the direct result of the prevention of fires. There never was a time when the shrubby lower foothills and desert mesas produced vegetation enough, except in limited localities, to allow fires to spread, but the grassy foothills, which constitute the upper half of our inclosure, produce sufficient vegetation to burn readily, at least every other year, at the present time. Previously, before the country was stocked, it probably produced more grass than it does now, and was frequently burned over, the fire extending as far down as vegetation would permit. Such burning did comparatively little injury to the grasses, but was very destructive to all small shrubs; consequently, these were able to exist only along the sandy washes, where the grasses were least productive, and upon the lower areas, where fires did not molest them.

> Upon the brushy deserts below, the rainfall is so scanty that the grass produced is not sufficient to allow fires to spread."

Thus it would seem that initial establishment of both burroweed and mesquite on the Santa Rita took place prior to fencing of the area and that subsequent protection from all livestock grazing was ineffective in eliminating these low value plants.

Grazing capacity was estimated from herbage production on plots (3x7 feet) clipped at the end of the growth season and from records of hay cuttings. Wooton's statement follows:

> "Assuming the value of 1,100 pounds per acre as an average total productivity and 50 percent of that amount as maintenance capacity for the range, then, if the average animal eats the equivalent of 30 pounds of dry feed per day he will need 11,000 pounds in a year, and it will take 10 acres of land to furnish that amount at full productivity, and 20 acres of land at maintenance capacity. Thus we have an average value for carrying capacity equal to 20 acres per head per year, or 32 head per section, for the reserve."

Subsequent experience since 1915 has shown that Wooton's estimates of grazing capacity were highly optimistic, but this is excusable because at the time they were made, no accounting was possible for the ever increasing depressive effects of mesquite and burroweed growth on forage production. Furthermore standards of proper use had not as yet been developed.

Formal publication, in bulletin form, of the results of the experimental work carried on since 1915 is largely lacking. The economic aspects of livestock production have been covered in detail by Culley ( ). Experience and research results on range management phases from the Santa Rita were drawn upon by Parker ( ) in the preparation of a popularly written war-time leaflet. The problem of mesquite invasion and its control was reported by Parker ( ). Results of reseeding studies are reported by Cassady and Glendening (   ). Aside from these four formal publications there are no others. However there have been numerous articles in technical and trade journals and mimeographed research notes relating to the various phases of range and livestock management and improvement of range lands through noxious plant control and reseeding.

Several manuscripts intended for Department publications are in the files of the Station, but for various reasons have never been given final approval. Three of these are noteworthy. The first, "Close Grazing and Forage Production in Relation to Preservation of Southwestern Semi-desert Ranges" (1936) by Matt J. Culley, was based on a clipping study of the important mixed grama grassland species. One or more worthwhile technical articles could be drawn from this material on the effect of herbage removal by clipping. The second manuscript, "Seasonally Deferred Grazing of Semi-desert Grasslands in the Southwest" (1938) by Matt J. Culley and George E. Glendening, apparently did not have adequate and sufficiently sound data to warrant publication. The third manuscript is now in process of preparation by Mr. Culley and summarizes the grazing management and handling livestock phases of the range research at the Santa Rita since 1915. Parts of this have already appeared in articles in stockmen's journals. It is hoped that this manuscript can be pushed through its initial publication phases before Mr. Culley's retirement and prior to the initiation of any new work on grazing management.

Significant major findings (in the opinion of the author) that are apparent from past grazing management studies at the Santa Rita, are as follows:

(1) Information on grazing capacity which will serve as a valuable

guide to proper stocking of similar range areas, particularly on the grassland and desert shrub types. However, in view of the continuing encroachment and ever increasing abundance of low value plants with their depressing effects on forage production, it is almost meaningless from a long time viewpoint in areas newly invaded with mesquite.

(2) Proper use figures for the major forage species are reasonably sound. But intensive, basic research is needed to learn the effect of utilization on the vigor of individual plants, species by species, and also on range condition.

(3) Although the evidence is admittedly weak (because there has been little study made of deferred grazing), yearlong grazing use is apparently a contributary cause to range deterioration, while rotation deferred use has several advantages.

(4) The numerous advantages, both to the range and the livestock, of maintaining a degree of stocking which provides ample forage throughout the year have been fairly well demonstrated. However, the effect of various levels of forage use, on livestock production and range condition, remains to be satisfactorily determined.

(5) The now ubiquitous mesquite and burroweed and the rapid encroachment of cholla cacti, (Opuntia fulgida), all of which are generally by accelerated erosion, are of great significance in future management of these lands. This is especially so since no degree of moderation in grazing use will eliminate these low value plants. The meaning, in unmistakeable terms, is that if we are to continue grazing use by domestic livestock some positive, drastic treatment which will eliminate these plants will be necessary to achieve conservation of the grazing resource.

In some cases reseeding will have to accompany the noxious plant control. In the future these improvements will have to be definitely provided for in a financial sense in many ranch operations just as much as any other improvement practice such as fencing and water development.

(6) The economic aspects, pertaining to ranch units operated on a conservative basis, have been well demonstrated. There is need for similar information on ranches not so well managed and habitually overstocked.

(7) Important ecological observations and findings have been made such as plant succession, the longevity of the major grasses, the effect of litter on germination and survival and the life history of jackrabbits and rodents. But this work is far from complete. More information of this type is needed to aid in management.

(8) Work accomplished on the Santa Rita has been hindered by attempting to observe vegetational changes on too large an area (50,000 acres) in view of the time and personnel available. Future work should be focused on a few intensively managed pastures in order to gain a better understanding of the effects on both range and animals.

Present status of work at Santa Rita.--Grazing management studies at the Santa Rita have been largely on a maintenance basis for the past ten years or more. The following records have been maintained and unless otherwise noted are still being maintained in continuity:

(1) Climate--records are mainly on air temperatures and precipitation. These records have been maintained since 1915 for the primary purpose of correlating plant growth with weather. The Botany and Range Ecology Department of the University of Arizona has assumed some of the

responsibility in maintenance and compilation of these climatic records.

(2) Vegetation records are maintained to determine the effects of grazing use and climate and consist of: (a) Meter square quadrats originally about 150 (30 protected) started in 1916 (majority in 1922) and concentrated largely in Pasture 2. These were last charted in 1934 (Canfield recharted a few selected ones in 1947). All have been summarized up to 1934, but show no consistent trend with grazing use or climate. Stakes are still in the ground and quadrats could be recharted if deemed desirable. (b) Pastures 2, 5, and 8 have been sampled with line transects each year for density, composition, and grazing use since about 1940. (c) Panel plots--16 in number located in Pastures 1, 2, 6A, 9, 10, 12A--originally charted 100 square feet with 10 divisional decagon frame in 1937 to 1939 inclusive. These were dropped because of too much other work. (d) A series of photopoints--some established as early as 1903--which are retaken intermittently. These photographs are among the best records as to changes in vegetation. (e) A series of enclosures, protected against livestock and in some instances rodents, have been well maintained and documented. (f) No specific records have been maintained on plant development.

(3) Forage crop is estimated each fall after the summer growth season by the following methods: (a) Ocular estimates in terms of percentage of the "average"--presented on a "forage crop map" since about 1922. (b) Panel plots, 50 located in all pastures. 100 square foot sampling plots where vegetation is clipped to proper height at end of summer growth season--started in June 1939 and still being maintained.

(4) Utilization of forage in each pasture is surveyed near the end of each grazing year (June). The major objectives of the utilization survey are: To form a record of year by year actual degree of grazing use in each pasture, to serve as a guide in periodic adjustment of livestock numbers, and as a means of developing methods for determining degree of use. Records of grazing use consist of: (a) an ocular survey wherein areas definitely grazed to the point of injury are indicated on a map--records maintained since about 1922, (b) randomized paced transects (see Research Note #105) beginning about 1940, (c) randomized line transect survey of pastures 2, 5, 8 (a cross-section of vegetation from desert shrub to mixed grama grass land), (d) detailed observations have been made in the past of grazing habits of cattle and forage preferences.

(5) Stocking records have been maintained as to actual numbers of livestock in each pasture since 1915. These are summarized for each cooperator on a fiscal year basis with respect to animal days use. Grazing charges are made at the rate of $2.00 per animal unit per year. Records have been maintained on livestock distribution within each pasture.

(6) Livestock records have been maintained by each cooperator and cover all years since 1915. They consist primarily of a record on costs and returns, death losses, calf crops, salt consumption, and marketing weights of cattle. These records formed the basis for Culley's ( ) economic bulletin.

The records listed above have since 1915 been considered as essential and as a minimum of observational data necessary to meet the basic requirements in grazing management and handling livestock phases of the range research at the Santa Rita. They now receive the full time yearlong service of the Superintendent, about 6 man months additional help during the field season, and about one man month clerical and statistical assistance.

Relationship with cooperators.—Relationships with the cooperating stockmen have varied from poor to good. In the past some of the cooperators (who fortunately in the early years of the operation sold out their grazing privileges) have actually been in trespass—that is grazed more livestock than prescribed by the agent of the Secretary of Agriculture. The greatest cause of disagreement has been the setting of stocking rates, the distribution of livestock, and the maintenance of livestock records in proper order. Grazing capacity and actual stocking rates are made in accordance with the instructions of the superintendent. Because grazing capacity has gradually declined since 1915 reductions in numbers of livestock have been required which have not always met with the approval of the cooperating stockmen.

The question of who should own the livestock grazed on the Santa Rita range, has been raised a number of times—some feeling that advantages would accrue from government ownership of the cattle and others that certain advantages accrue from private ownership plus the added advantage of acceptability of results by surrounding stockmen. A third possibility has been mentioned—that of stock ownership by the University of Arizona and full participation by them in the research program.

From a strictly research viewpoint there would undoubtedly be a distinct advantage in government ownership which would allow absolute control of grazing use. It would eliminate the consideration that the scope of the work, or methods employed, be altered to benefit the cooperating cattlemen dependent on the operations for their livelihood.

Better control would also result under ownership of stock by the University of Arizona. Both systems of public ownership would probably make difficult the securing of economic data on the outfits as range operations.

Perhaps a more desirable basis of operation would be one under which certain pastures were devoted to intensive research with either the government or the University of Arizona owning the stock (or they could be furnished "at the gate" by the cooperating stockmen), with the balance of the range operating as at present under cooperative agreements and used as a practical proving ground for the results developed in the intensive research areas. In short, this would turn the parts of the range, operating under cooperative agreements with private individuals, into practical proving grounds and demonstration areas.

Cooperative relations with other agencies:--Cooperative relationships with other agencies have been encouraged since 1915. Noteworthy among the agencies cooperating are: University of Arizona, Carnegie Institution of Washington, the Fish and Wildlife Service, and the Soil Conservation Service. On the whole, arrangements that have been consummated for undertaking various phases of the work have proven highly satisfactory to the parties involved. Cooperation has varied from merely furnishing facilities, or a place to work, to actual joint field attack on problems of mutual interest.

Cooperative work has in the main been in connection with range reseeding, noxious plant control and studies of rodents (life history, relationship to range condition and forage requirements). There has been little or no cooperative work directly related to the grazing management and handling livestock phases. It would seem especially advisable to encourage cooperative work with the Animal Husbandry Department of the University of Arizona in view of their interest (they, during the past year or so, have been attempting to secure control of Ft. Huachuca Military reservation for their experimental work) and their position with respect to being able to get research findings into practice. Cooperative work is now in progress with the Botany and Range Ecology Department of the University, in connection with range reseeding (also the Soil Conservation Service) and noxious plant control.

Studies of jackrabbit and range-forage destroying rodents, initiated by the Fish and Wildlife Service, were terminated by the War. It is hoped that these studies can be resumed by the assignment of a full time technically trained man.

Plans for future work at the Santa Rita.—Prior to undertaking any new research in grazing management and handling cattle at the Santa Rita, all past data and experience should be carefully summarized, analyzed, and prepared for publication. This phase of the work is now well advanced. An additional worthwhile project at this time would be the story of the Santa Rita for the period 1903 to 1948. This would include the significance of the changing character of the vegetation in terms of forage production and accelerated erosion. For example, total herbage production for the area, as estimated by the Bureau of Plant Industry during the period 1903-1914 averaged over 1000 lbs per acre annually whereas it is now about 150 pounds. Additional information would be forthcoming by a recharting of all quadrats. A leading basis for the paper would be the wealth of photopoints that are available for repeat photographs. This job would require a minimum of one man years time.

In planning future grazing management work at the Santa Rita it should be borne in mind clearly that the major problem confronting the livestock industry in the semidesert range province is that of conserving and restoring the range for grazing purposes. To reach this objective, intensive research will be required on at least four major phases of the problem, namely: (1) The effect of elimination of low value plants on forage production and the arresting of accelerated erosion, (2) yearlong vs. seasonal deferred grazing, and (3) animal and vegetational effects of heavy yearlong grazing compared with moderate yearlong grazing use, (4) restoration of deteriorated range through artificial revegetation(this work was initiated in 1945).

Each of these studies will have to be carefully conducted on a pasture basis in terms of actual poundage of livestock and forage production. To carry out these studies it is proposed that certain areas be fenced and stock water provided. The remainder of the area used by each of the cooperators would be managed much as it has been in the past but would be subject to change whenever the findings from the new studies indicate the need for further widescale demonstration and testing.

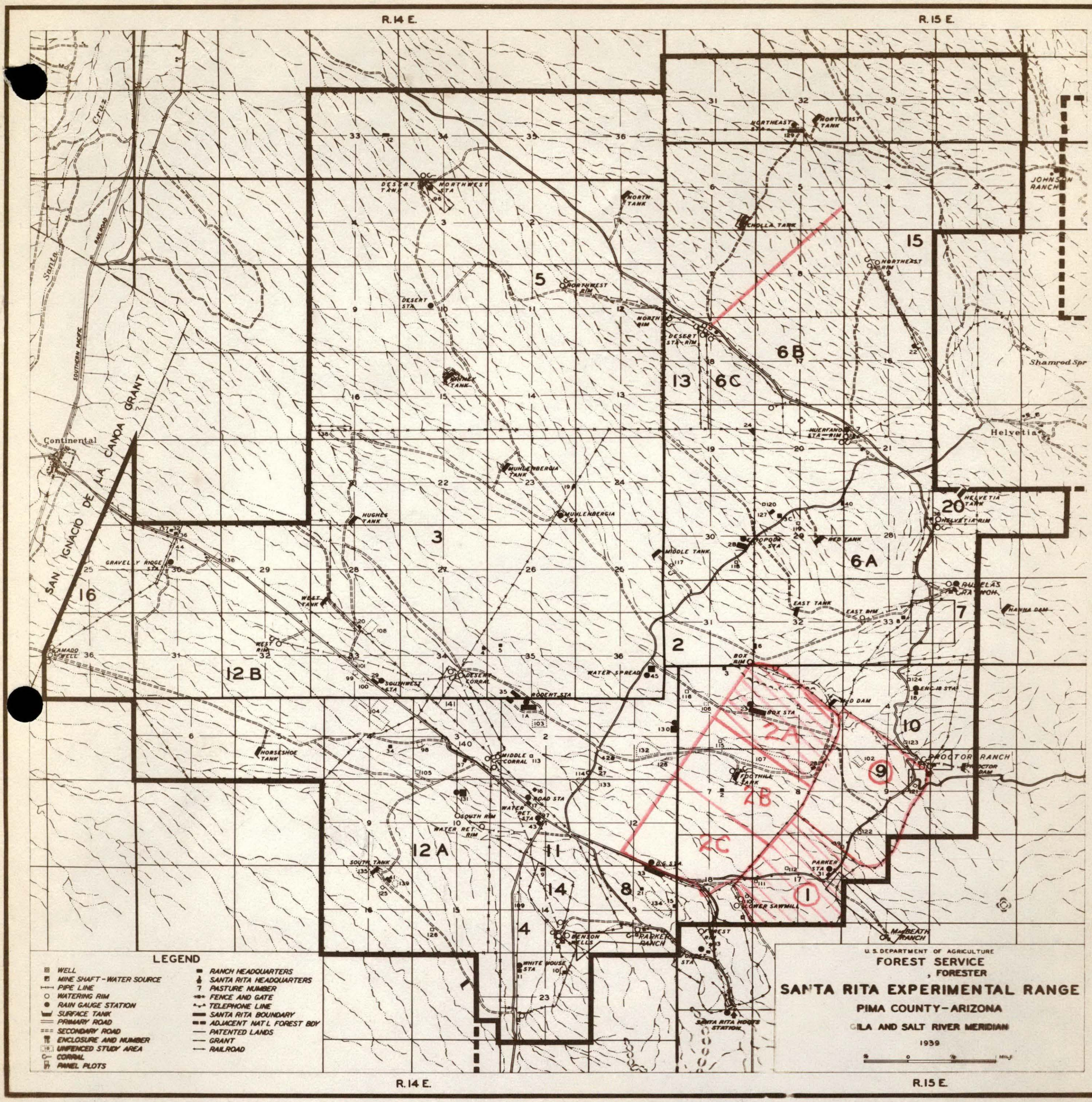
As previously pointed out, the stocking policy since 1915 on the Santa Rita has been and still is based on stocking the pastures with a more or less rigid number of breeding cows fixed at an estimated rate to determine grazing capacity. These numbers are adjusted but little from year to year (except in times of major drought such as we are now experiencing 1947-1948). However, the rate of stocking through the years has been gradually reduced. For example, Pasture 2 has dropped from 432 head yearlong in 1915 to 130 head in 1947. It is possible that the 432 head agreed upon in 1915 as being "proper", may have actually represented overstocking in the light of present day standards. But we should recognize and appreciate that it was originally set up as being "moderate" according to the best judgment of the men in charge of the work at that time and with little information available. Furthermore, mesquite was largely confined to the drainage areas and occurred as scattered bushes in the intervening grasslands. With further encroachment, increase in abundance and increase in size of individual plants, the demands for moisture likewise sharply increased and this resulted in a gradual and inexorable reduction of moisture available for forage production. Thus, through the years reductions in stocking rates have been necessitated. Since these plant invasions are still in progress, cognizance of this phenomenon will have to be taken in any new grazing management research. There has been little or no recognition of the effects of yearlong grazing employed as a comparison with rotation--deferred grazing--and yet the latter has been repeatedly recommended as a means of range improvement. This has been done largely on the basis of observation of seasonal deferment in Pasture 9, which is now on a yearlong basis. The following suggested grazing management studies are outlined:

(1) A study to compare the effects of rotation-deferred grazing and mesquite removal with yearlong grazing both with and without mesquite removal. A minimum of five pastures (if funds are available the pastures

should be replicated) would be required, see figure __, making use of Pastures 9 and 1 and subdividing three pastures designated as 2A, 2B, and 2C in the southeast part of Pasture 2. Yearlong grazing would prevail in pastures 1 and 9 and mesquite would be eliminated in one of these (probably Pasture 1). Pastures 2A, 2B, and 2C would be grazed with the same herd on a rotational-deferred system--wherein each of the pastures would be systematically and periodically protected from grazing use during the growth season. On one of these pastures all mesquite would be eliminated. Records would be maintained on all pastures regarding range condition, forage, and livestock production. Panel plots would have to be set up within the pastures to determine the effects of repeated long time seasonal use on the same area since this is no replication of pastures. To set up the study would require an initial outlay of $12,000 consisting mainly of five miles of fencing ($2,000), three miles of pipe ($3,500), livestock scales and corrals ($1,500), 1200 acres of mesquite control ($6,000), miscellaneous equipment($1,000). It would require the full time services of a P1 or P2 grade technician.

(2) A study to compare the effects of heavy vs. moderate yearlong grazing on forage and livestock production. The major purpose of this study would be to demonstrate the economics involved in range conservation. The study would at least partially fulfill the suggestion made in the Loveridge-Cliff Report of 1945 (see item 6, Page R1) which is quoted in detail in the next section pertaining to future research at the Jornada.

The heavy grazing would simulate the type of grazing use characteristic of much of the outside privately managed ranges whereas the moderate grazing use would be based on our own knowledge and experience. To set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U.S. DEPARTMENT OF AGRICULTURE
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SANTA RITA EXPERIMENTAL RANGE
PIMA COUNTY–ARIZONA
GILA AND SALT RIVER MERIDIAN
1939
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LEGEND
WELL
MINE SHAFT – WATER SOURCE
PIPE LINE
WATERING RIM
RAIN GAUGE STATION
SURFACE TANK
PRIMARY ROAD
SECONDARY ROAD
ENCLOSURE AND NUMBER
UNFENCED STUDY AREA
CORRAL
PANEL PLOTS
RANCH HEADQUARTERS
SANTA RITA HEADQUARTERS
7 PASTURE NUMBER
FENCE AND GATE
TELEPHONE LINE
SANTA RITA BOUNDARY
ADJACENT NAT'L FOREST BDY
PATENTED LANDS
GRANT
RAILROAD
SAN IGNACIO DE LA CANOA GRANT
Continental
Santa Cruz
SOUTHERN PACIFIC RAILROAD
Helvetia
Shamrod Spr
JOHNSON RANCH
PROCTOR RANCH
RUELAS RANCH
HANNA DAM
McBEATH RANCH
BENSON WELLS
PARKER RANCH
SANTA RITA HDQTS STATION
LOWER SAWMILL
NORTHEAST TANK
NORTHWEST TANK
DESERT TANK
NORTH TANK
CHOLLA TANK
MULENBERGIA TANK
HUGHES TANK
WEST TANK
HORSESHOE TANK
SOUTH TANK
MIDDLE TANK
RED TANK
EAST TANK
FOOTHILL TANK
HELVETIA TANK
DESERT CORRAL
MIDDLE CORRAL
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Notes

Figure 15. Proposed additional pastures for grazing management studies. New fencing shown in red, cross hatching represents mesquite elimination.

up the study would require $4,000, mainly for two miles of fencing (subdividing 6A or 6b)($800.), 1-1½ miles of pipe $1,500), and miscellaneous equipment ($1,700). Scales and corrals are now provided at Desert Rim. The study would require full time services of a P1 or P2.

(3) Continuation of remaining portions of Santa Rita as practical cattle ranch demonstrations and management continued on present basis but subject to change whenever deemed necessary for further demonstration of findings brought out in other studies--particularly in study phase listed as (1) above. Would require one P1 grade technician.

The three technical grade men, together with the Superintendent, with student assistant help during the field season would provide manpower--sufficient to gather the factual information of the studies listed above and would also permit securing information on outside ranges and giving advice and guidance to national forest adminstration in setting up demonstration allotments. However considerable assistance would be required from the Botany and Range Ecology and Animal Husbandry Departments of the University of Arizona and the Fish and Wildlife Service to complete the over all picture.

RANGE RESEARCH AT THE JORNADA EXPERIMENTAL RANGE

Purpose of Establishment.--The Jornada Experimental Range, near Las Cruces, New Mexico, comprising some 193 thousand acres, was set aside by Executive order May 12, 1912,--for "experiments in the improvement of pastures and breeding of horses for military purposes." In the beginning, the experimental work was under the direction of the Bureau of Plant Industry. Events leading to the initiation of the work, and the formulation of original major objectives are well described in the following letter dated November 2, 1936, from E. O. Wooton, formerly associate agricultural economist of the Department of Agriculture:

> In talking over the work with Dr. Griffiths, I said that the best data in the records (Santa Rita) were the figures showing the "animal-days" feed furnished to cooperators' stock by known areas of land. (One of the principal things we were trying to measure was what everybody called (and some still call) "carrying capacity"; (better called by Potter's name, "grazing capacity"). Griffiths said "yes, I know that." But, I said "our data are from too small an area of land and the areas used are more productive than the average for the region." He agreed to this, but asked "How are we going to get data from a larger area? We have no money for a fence and can't get any."
>
> I knew that Mr. C. T. Turney of Mesilla, New Mexico, was an experienced and reliable cattleman who "owned" a large ranch, most of which was public domain. I knew that he wanted very much to improve his ranch and had done all he could to get it fenced. I knew that Director Luther Foster of the New Mexico Agricultural Experiment Station was in sympathy with the idea and anxious to have experimental range work done in that region.
>
> The three of us met as planned, and Mr. Turney said he would willingly pay ordinary forestry fees in order to get his range enclosed, and would build and maintain all the fences and other structures necessary. I told him we did not want money, but did want information. After explaining that we would want data as to numbers and movements of stock, some relatively small selected areas for recovery and planting experiments, which need not interfere with his ranch operations, etc., he said he would gladly cooperate with us to the best of his ability.

> Our principal desire was to obtain accurate data on grazing capacity on a large area. We expected to let Mr. Turney run the ranch as he would do if it were his own land, and compare the results with those on ranches on the open range from which we could get data. Mr.Turney knew more in five minutes about managing a cattle ranch than I would ever know. We all thought we knew that proper management of stock and care of the feed would result in improvements of many kinds, and we wanted to prove the correctness of our faith by seeing it occur and keeping as accurate records as possible of the progress and rate of improvement.

The first cooperative agreement between C. T. Turney and the Secretary of Agriculture, dated January 25, 1913, set forth the objectives of the work as follows:

> "(a) The rate of recovery of depleted ranges under conditions of complete rest and partial stocking.
> (b) The normal carrying capacity of the natural ranges of that region.
> (c) The possibilities of range improvement by introduction of new plants, seed planting, conservation of run-off, etc.
> (d) The methods of range management."

As mentioned previously, the responsibility for the experimental work at the Jornada was transferred from the Bureau of Plant Industry to the Forest Service in 1915. During the 30 or more years of its existence the main objectives of the experimental work have been set forth from time to time in the various cooperative agreements and are quite similar in intent to those previously presented for the Santa Rita. Research work has included study of:

(1) The grazing capacity of semi-desert yearlong, ranges.

(2) Methods of range management which will conserve and improve the range, protect the rancher in times of drought and produce more beef at less cost.

(3) The rate of recovery of deteriorated ranges under conditions of both complete rest and of partial stocking.

(4) The possibilities or range improvement through range reseeding, conservation of run-off and noxious plant control.

(5) The economics of livestock production on semi-desert grassland range.

Research findings are applicable in greater or less degree to some 43 million acres of semi-desert range found in West Texas, and southern New Mexico. Many of the principles of management are applicable to an even wider scope of country. Research findings have been made available to stockmen through numerous publications, demonstrations, and ranch Day programs held in cooperation with the New Mexico Agricultural Experiment Station, New Mexico Agricultural Extension Service and other State and Federal agencies interested in production of livestock and range conservation.

Past Results and Pertinent Findings.--Past results of the experimental work in grazing management at the Jornada have been periodically reported in formal publications and in numerous articles for technical and livestock journals. The major formal publications are those by Jardine and Hurtt, ( ), Jardine and Forsling ( ), Forsling ( ), Nelson ( ), Canfield ( ), and Campbell and Crafts ( ).

In reviewing this material it should be kept in mind that the major objective was to determine grazing capacity and proper range management in an area fraught with many uncertainties of climate, especially the hazards of ever recurring drought. In general, the grazing practices followed have been determined by the growth requirements of the vegetation and the variable forage crops necessitating an extremely flexible stocking policy. These factors were early recognized by Jardine and Hurtt (   ) but unfortunately their figures on "carrying capacity" were based on only three years (May 1, 1913 to May 1, 1916). In the light of the average stocking rate during the past 10 years (about 1100 head) the following, their statement, is of interest:

> "Taking into account the surplus or shortage of forage in each of the thirteen pastures, the estimated carrying capacity of the whole Reserve in its present condition and stage of development is 5,030 head throughout the year, not including unweaned calves. This is at the rate of 38.1 acres per head. The Reserve would no doubt carry this many, provided, as at present, supplemental feed were used to prevent the loss of poor cows. This would be necessary in a measure if only 4,000 head were grazed, as there would still be some stock in need of special attention. These figures for the Reserve as a whole are of interest merely as showing average carrying capacity over a large territory, combining plains, foothills, and mountain range, such as is found throughout southern New Mexico outside of the National Forests."

In a later bulletin (1922) Jardine and Forsling (   ) pointed out that the problem of drought, as related to cattle production, could be met by limiting the breeding herd to the grazing capacity of the range during drought and varying the numbers of surplus stock in accordance with forage production. The stocking policy adopted was expressed as follows:

> "The situation calls for an adjustment in the business that will permit obtaining the maximum use of the forage produced in good years, but at the same time will permit orderly reduction in the number of stock in time of drought without loss.
>
> Using as a basis the data on the volume of range forage which may reasonably be expected annually over a period of years including a drought and the effect of this variation upon grazing capacity or percentage of stock grazed each year,....it remains to decide upon the class of stock and their numbers and management annually and for a period of years including a drought."

However, in view of subsequent happenings, stocking rates, as were recommended by Jardine and Forsling, were still too high. Con-

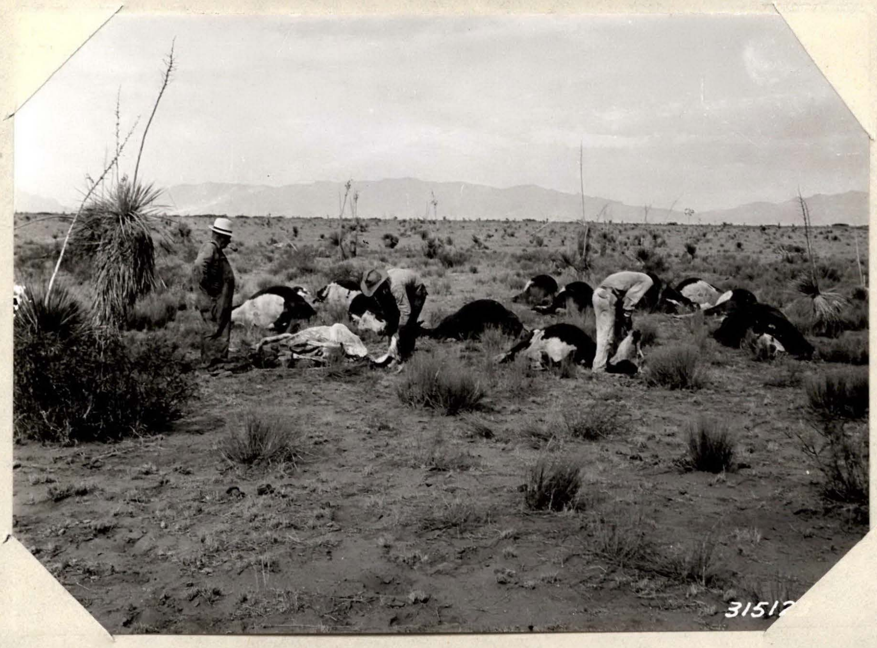

Figure 16.--Drought is an ever present threat to successful range management in the Southwest. Animals killed in drought relief program 1934-1935-- in this case the hides are being salvaged.

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siderable effort was expended in securing information on saving livestock from starvation by the use of supplemental feeds and emergency use of soapweed, and other plants normally of low palatability to tide the animals over periods of forage shortage. These findings were reported by Forsling ( ). It has been only with the passage of time and the experience gained in such terrible droughts as that of 1934-1935 that a more rational and conservative rate of stocking, together with a flexible herd, has been proven to be the most sound method of management in the semidesert range province.

Data on the fluctuations in rainfall, and the resulting variation in forage crop, have been collected at the Jornada since 1915. The average year's forage crop for the Jornada Experimental area, over a 27 year period, expressed in animal units, is 1739. If the Jornada had been stocked on this average there would have been only 13 years out of the 27 year period when the forage supply would have been sufficient to carry that number of livestock on the range. On the other hand, if the range had been stocked (as it has been since 1938), at 65 percent of the average, (1130 animal units), 24 years of the 27 year period would have provided a safe basis of stocking, and this would have provided reserve forage in some of the leanest years. This is one of the major lessons gained from the Jornada operation. Another lesson relates to the importance of herd flexibility in management of semidesert range, as presented by Ares, (unpublished manuscript 1947). Another manuscript of leading importance, relating to grazing capacity and prepared by Campbell, Chapline and Shoeller, now awaits further revision before formal publication. Other publications that have been of value in range management are those of Nelson, ( ) on the influence of climate and grazing on black grama; Canfield's work ( ) on the effect of intensity and frequency of herbage removal on density and yield of black grama and tobosa grass; and Campbell and Crafts, ( ) publication on how to maintain black grama on Southwestern ranges. The numerous technical articles by R. S. Campbell have been outstanding contributions to a better understanding of the ecological relationships involved in semidesert range areas.

Present Status of Work at Jornada.--As is the case on the Santa Rita, the Jornada is being operated on a strictly maintenance basis. It has been something of a "one-man-show" since the beginning of World War II, with a full time man and about six man months of additional help during the field season, this in addition to assistance in office compilations. The aim has been to maintain in continuity all records of value in the grazing management and livestock handling phases of the research. The following records are being maintained:

(1) Climate: Records are being maintained at the Jornada headquarters on most of the climatic factors including precipitation, temperature, evaporation, relative humidity and wind. In addition to this there are 23 rain gauges scattered at various points on the range. A weekly report on weather is submitted to the Bureau of Agricultural Economics and the Weather Bureau. Time required for gathering and recording this climatic information is about one man month per year.

(2) Vegetation: Records are maintained to correlate with the effects of grazing use and climate. Records consist primarily of:

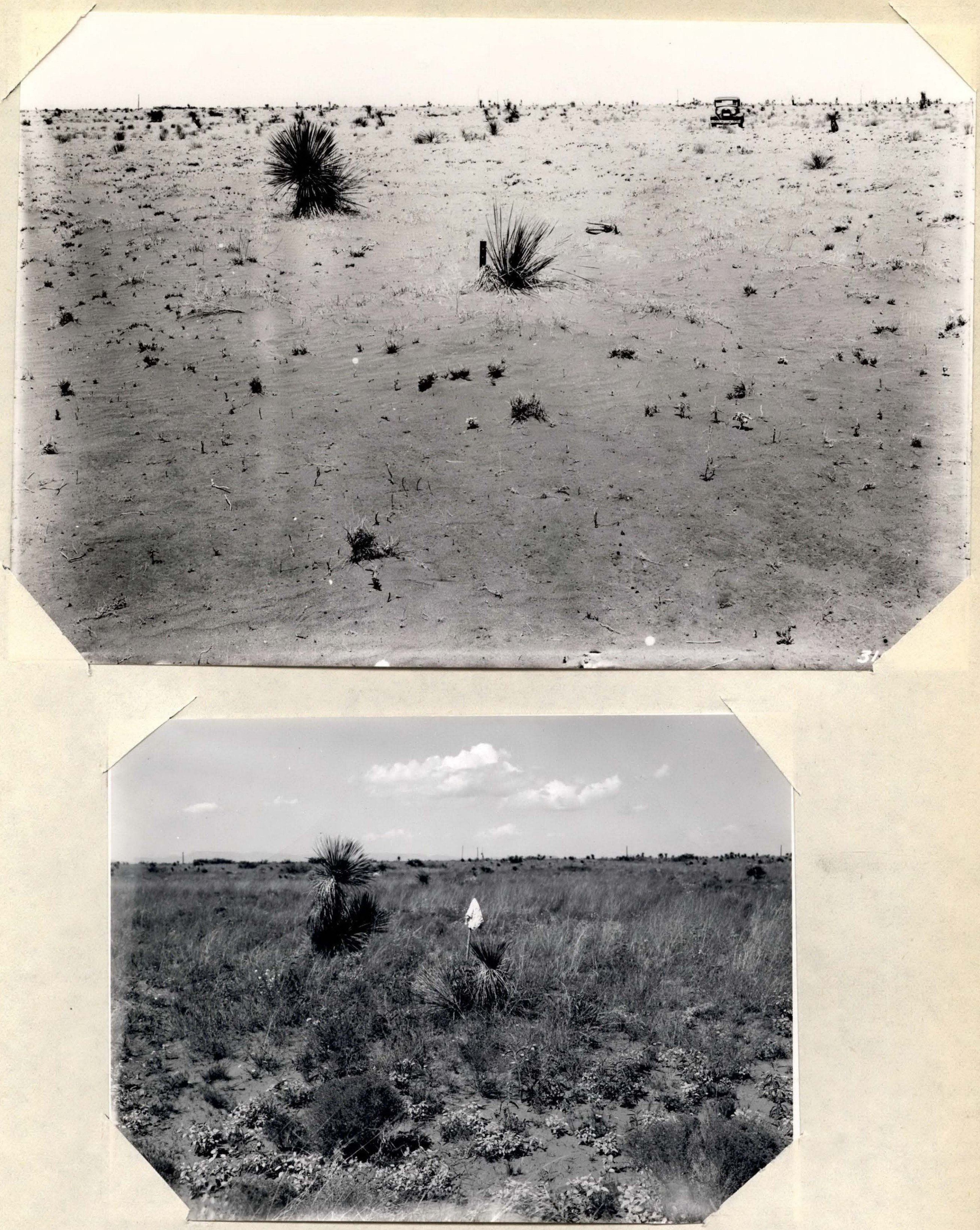

Figure 17.--Upper photo taken in 1935 following 1934 drought, lower photo in 1947 (also a drought year but most of the rain came in August) from same photopoint--Jornada Experimental Range. Recovery is attributable to higher stocking, a flexible breeding herd, and a more rigid policy with regard to summer deferred use on black grama.

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a. Some 100 meter square quadrats which are charted each year and a great many of which were initiated in 1915 and 1916. These are charted, usually in September, and require about two man months field time per year. An example of the use of this information is Nelson's (   ) technical bulletin.

b. The black grama areas are sampled each fall by measured randomized transects at the same time that the forage crop data is secured.

c. Numerous enclosures fenced against livestock and in some instances rodents.

(3) Forage crop: Inventory is made in the first week of October. On the black grama areas some 200 randomized clipped transects are recorded. Ocular estimates are made on the forage crop on the remainder of the Jornada. In addition to this, a mid-winter ocular survey is made of the spring forage crop. These two jobs require about four man months for field work and office compilation.

(4) Utilization of Forage: Each pasture is measured at the end of the grazing year, in June, on the black grama areas, by randomized, paced transects and for the remainder of the experimental area by ocular estimate. This job requires about two man months.

(5) Livestock: Records have been maintained since 1915, on all pastures, in relation to actual numbers grazed. This information is provided by the cooperator and checked at the end of each month. The figures during recent years have been entered into the standardized forms devised by Mont Saunderson. This is likewise true of all other records pertaining to livestock such as calf crops, shipping weights,

cash receipts, labor, and other operating expenses, and an inventory record. Livestock weights for the period 1915 to 1930 are fragmentary. Maintenance of all these records requires about six man weeks per year for maintenance.

The records listed above, have, since 1915, been considered as a minimum of information necessary to meet the requirements in the grazing management and livestock phases of range research at the Jornada range. One of the greatest difficulties in interpreting the records has been the attempt to follow vegetational changes that have occurred on this vast area of some 190 thousand acres with the manpower available. Unlike the Santa Rita, the Jornada has not been too well documented by photopoint stations. In the time that Wooton was there in 1912, he made many photographic exposures but unfortunately most of them were failures because of faulty mechanism of the camera. On the other hand, most of the meter square quadrats have been recharted annually.

Relationships with cooperator.--Relationships with the cooperator have varied from poor to good. The greatest causes of disagreement lie in questions regarding stocking rates, movement of livestock, setting up "checks" on various operational phases, supplemental feeding and maintenance of records--particularly those which involve securing weights of cattle. The cooperator has not always been appreciative of the major purpose of the Jornada in being an experimental setup and not just a "ranch." Part of this lack of appreciation has no doubt been due to failure of the Department of Agriculture representatives to inform the cooperator properly as to the objectives of the work and let him in on the "know." Part has been due to the desire of the cooperator to secure a maximum financial return with a minimum outlay for labor and a minimum of handling of livestock. Cooperation with the present cooperator, B. A. Christmas, has been more cordial and enthusiastic than with any of the previous cooperating stockmen, but as in the case of the Santa Rita Experimental Range, federal or state ownership of the livestock would lose many of the difficulties with regard to disposition and control of animals. It would, however, eliminate the desirable aspect of having the results forthcoming from a practical ranchman and thus rendering them more acceptible to livestock people in general.

Relation Between Work at Jornada and New Mexico A & M.--In 1927, the New Mexico College of Agriculture and Mechanic Arts secured control of some 63 thousand acres of range adjacent to the Jornada, through purchase and Congressional Act. The experimental work at the College ranch has been supervised solely by the Animal Husbandry Department. Outstanding contributions have been made in animal nutrition studies, particularly with reference to calcium-phosphorus deficiencies of range forage and what can be done to correct these deficiencies in the way of feeding mineral supplements to range livestock.

Other studies have included various phases of animal breeding--tracing the effect of sire and dam on the offspring from the range on through the feedlot; comparison of returns from steers and breeding cows productivity, and chemical composition of range forage.

During the CCC era, the College Ranch was cross-fenced into relatively small pastures and stock water developed. This was done primarily to accommodate small lots of cattle (about 20-25 head in each pasture) in order to enable expansion of the mineral nutrition and animal husbandry phase of this work.

About 1935, the Animal Husbandry Department secured additional funds under the Bankhead-Jones Act for undertaking experimental range work. This project provided for studies of controlled grazing, utilization of run-off water, noxious plant control, and reseeding. During the past decade a large portion of these funds have been expended on reseeding studies. Surprisingly enough, there has been little or no duplication of effort between the work of the New Mexico Station and the projects under way on the adjoining Jornada Experimental Range. Actually, the experimental work of the two institutions has served to form a well rounded program of cooperative range research. The closest approach to duplication is that of reseeding--and agreement has been reached between the two institutions to avoid this.

At the present time, the Animal Husbandry Department is gradually expanding its range work and now employs two men who spend their full time on problems of range management (which also includes teaching responsibilities). It is possible that in the future there will be an increasing overlap in grazing management studies but the field is so large this should not present any conflict for some years to come.

Plans for Future Work at the Jornada.--The question has been raised from time to time by National Forest Administration as to whether or not the Southwestern Forest and Range Experiment Station has too many "eggs in one basket." In other words, whether we should give careful consideration to reducing the amount of money expended in maintenance of the Jornada and expend the amount saved on forest range problems.

The answer to this is that since the Jornada is now on a strictly maintenance basis, we cannot expend less money without closing the operation altogether.

The writer agrees that continuation of the Jornada, on the present basis of operation, would be inadvisable. At the time the Jornada was fenced, about 1912, it was ahead of its day as a practical, modern ranch set up. It can no longer be considered so, In the first place, from a research standpoint, the area is too large to observe closely in regard to the effects of management. From a practical ranch viewpoint, the pastures are too large for efficient livestock management--for example, Pasture 1 is 83,585 acres, Pasture 2 contains 32,115 acres, and Pasture 11 has 41,615 acres. There are few ranches in New Mexico with pastures this size and the trend within recent years is to subdivide into smaller pastures in so far as economic limitations will permit. Furthermore, there are not enough pastures to allow the proper segregation of various cattle classes and follow proper animal husbandry practices.

If the Jornada is to be continued as a practical demonstration of proper management, additional fencing and water development will have to be provided. This matter, together with a suggested management plan, has been considered previously (see Ares Jan. 27, 1942, R-SW Grazing Management Yearlong Ranges, Jornada Pastures memorandum). Although some features of this proposed new pasture arrangement will require further consideration, it is on the whole, logical and sound. In order of priority, the plan provides for the subdivision of: Pasture 2 into three pastures (separating black grama from the sandhills);

Pasture 6 into two pastures (one mostly burrograss, the other mixed tobosa--alkali sacaton); Pasture 1 into 3 pastures (separation of mesquite sandhills, creosotebush, and grassland). This would require 25 miles of fencing and the drilling of one new well at a total estimated cost of approximately $15,000. Such subdivision (see figure) would not only permit a more effective management plan for both range and livestock but would permit a more intensive study of grazing management problems. Justification for continuance of future work at the Jornada, in the opinion of the writer, depends on increasing the intensity of effort through the provision of the above added research facilities.

Studies which are needed to solve over-all regional problems, and which should be initiated, include: (1) Effect of rate of stocking and season of use on range condition and livestock production, (2) distribution of livestock through salting and water control, (3) relative productivity of various range types, and, (4) supplemental feeding, (5) handling livestock. Since limitations of funds, manpower, and suitable areas to do the work will prohibit undertaking all of these study phases at one time, further discussion appears warranted and is provided as follows: (1) Study of effect of rate of stocking and season of use on range condition and livestock production in the black grama type: the New Mexico Agricultural Experimental Station has suggested (and it has been borne out by observations on the Jornada, Santa Rita, and outside ranches) that condition of livestock together with animal production should be an index to the grazing conditions on a range unit. That is to say: where the cattle, year after year, weigh 1000 pounds on the average, the calf crop will average better than 90 percent with 8 month old calves weighing 400 pounds at weaning time provided that other factors of management such as bull ratio, distribution, proper culling, etc., are properly provided. Under such conditions the volume of forage, and hence range conditions in general, are bound to be good. On the other hand, where cattle year after year weigh, for example, 750 pounds (which is the average weight in New Mexico), the calf crop will be about 50 percent, and average about 320 pounds per calf. Whenever this level of production occurs year after year then range forage must be insufficient for normal growth and production and hence the range will be in an unsatisfactory condition. On an animal nutrition basis, the New Mexico station has a good deal of factual evidence to support its conclusions. Part of the evidence is based on analysis of survey figures of individual ranch units part on grazing management experiments carried out under actual range conditions, part on the data of the Missouri Agricultural Experiment Station on the normal growth of range livestock and the effect of feeding a ration 30 percent below that required for maximum growth, and partially on the net energy requirements as set up by Armsby, (Nutrition of Farm Animals).

When these data are applied to the State as a whole it indicates that over 40 percent of the forage in New Mexico is wasted in the maintenance of non-producing animals. If it can be demonstrated or proved experimentally that a smaller number of cows in good condition, averaging better than 900 pounds, will give greater returns per unit area of range than a greater number of animals weighing around 750 pounds, the information would be of real value to stockmen and range administrators.

To secure this information it is proposed that a cooperative study be arranged with the New Mexico Agricultural Experiment Station. Pastures 9 and the lower part of 2 on the Jornada, together with two adjacent College Ranch pastures would permit 3 levels of stocking (heavy, moderate, and light) on a yearlong basis, with a fourth group of cattle carried seasonally--wintering on black grama and summering on tobosa range. In order to obtain information on the effects of various levels of stocking on animal growth and development it would be necessary to begin the experiment with heifer calves. The proposed study does not provide for replication of pastures. If sufficient funds are available for fencing and water development this should by all means be provided - otherwise, information on the range phase will have to be supplemented with data from panels or even large (20-40 acres) fenced plots replicating the grazing use on the larger pastures.

The proposed study would fulfill in large measure the suggestion of Loveridge and Cliff made in 1945 (item #6 - page R1):

> "A change of range research practices on both the Santa Rita and Jornada Experimental Ranges would be desirable so that administrative officers and practical stockmen can see on different areas the condition of the range under several different rates of stocking - just as one may visit experimental forests and observe on different units, what may take place when cutting has been at the rate of 20% or 40% or 80% etc."

(2) Study phase on distribution of livestock through salting and water control.

Studies, as carried on at the Jornada, of salting away from water have yielded worthwhile, practical information which has been invaluable in securing better use of our grazing resource. However, the results have not been entirely "sold" to cattlemen. Our southwestern cattlemen generally view with suspicion the suggestion that we salt away from water.

Proposed Fencing

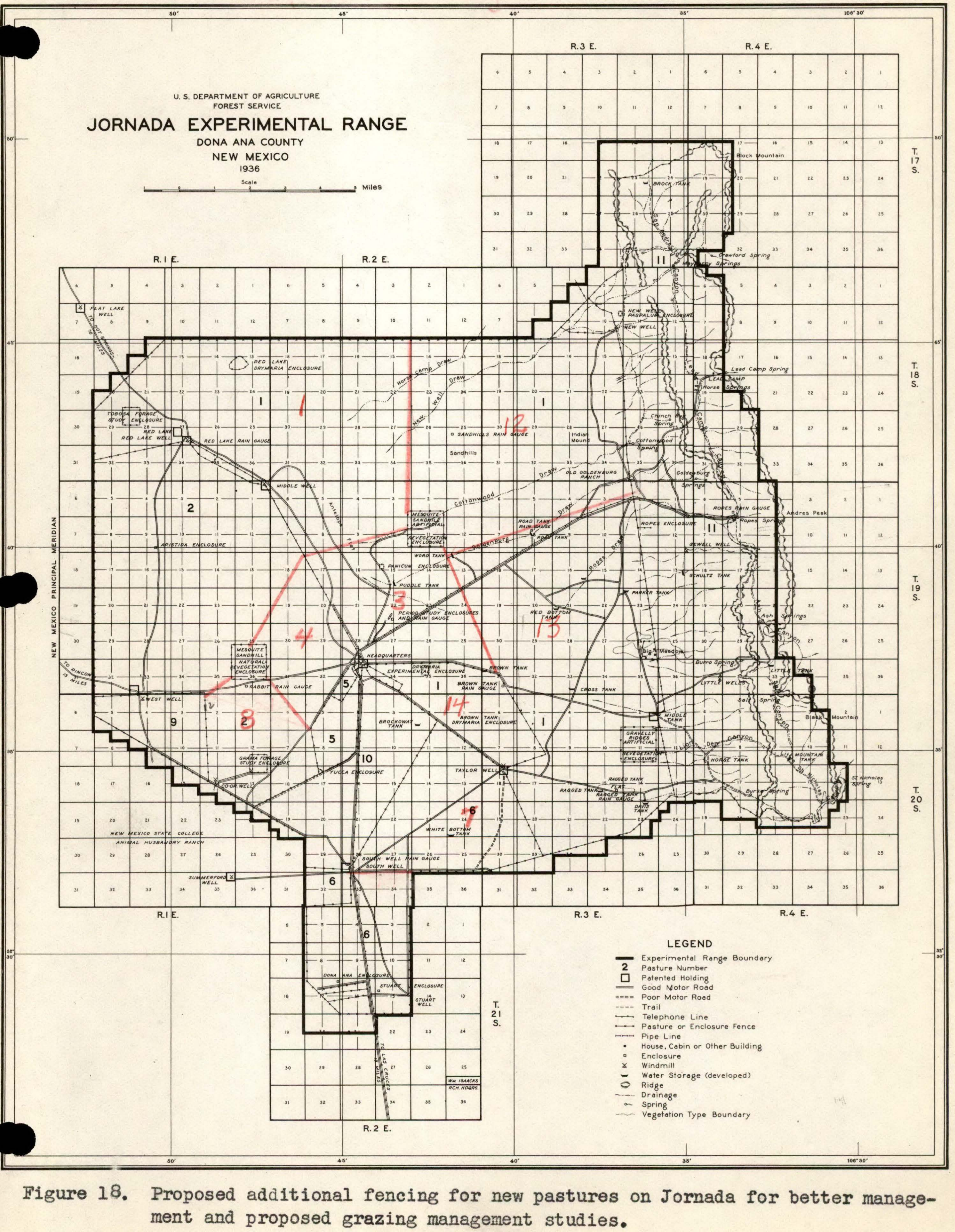
U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
JORNADA EXPERIMENTAL RANGE
DONA ANA COUNTY
NEW MEXICO
1936
Scale
0 1 2 3 4 5 Miles
R. 1 E.
R. 2 E.
R. 3 E.
R. 4 E.
T. 17 S.
T. 18 S.
T. 19 S.
T. 20 S.
T. 21 S.
NEW MEXICO PRINCIPAL MERIDIAN
50'
45'
40'
35'
106° 30'
32° 30'
FLAT LAKE WELL
TO HOT SPRINGS 70 MILES
TOBOSA FORAGE STUDY ENCLOSURE
RED LAKE
RED LAKE WELL
RED LAKE RAIN GAUGE
RED LAKE DRYMARIA ENCLOSURE
MIDDLE WELL
ARISTIDA ENCLOSURE
TO RINCON 15 MILES
WEST WELL
MESQUITE SANDHILL NATURAL REVEGETATION ENCLOSURE
RABBIT RAIN GAUGE
GRAMA FORAGE STUDY ENCLOSURE
CO-OP. WELL
NEW MEXICO STATE COLLEGE ANIMAL HUSBANDRY RANCH
SUMMERFORD WELL
Horse Camp Draw
New Well Draw
Antelope Flat
Cottonwood Draw
SANDHILLS RAIN GAUGE
Sandhills
Indian Mound
OLD GOLDENBURG RANCH
MESQUITE SANDHILL ARTIFICIAL REVEGETATION ENCLOSURE
WORD TANK
Goldenburg Draw
ROAD TANK RAIN GAUGE
ROAD TANK
PANICUM ENCLOSURE
PUDDLE TANK
PERIOD STUDY ENCLOSURES AND RAIN GAUGE
HEADQUARTERS
DRYMARIA EXPERIMENTAL ENCLOSURE
BROWN TANK
BROWN TANK RAIN GAUGE
BROWN TANK DRYMARIA ENCLOSURE
BROCKOWAY TANK
YUCCA ENCLOSURE
TAYLOR WELL
WHITE BOTTOM TANK
SOUTH WELL RAIN GAUGE
SOUTH WELL
DONA ANA ENCLOSURE
STUART ENCLOSURE
STUART WELL
TO LAS CRUCES 18 MILES
WM. ISAACKS RCH. HDQRS.
RED BOTTOM TANK
PARKER TANK
CROSS TANK
MIDDLE TANK
GRAVELLY RIDGES ARTIFICIAL REVEGETATION ENCLOSURE
RAGGED TANK
RAGGED TANK FLAT
RAGGED TANK RAIN GAUGE
DAVIS TANK
HORSE TANK
Ropes Draw
ROPES ENCLOSURE
ROPES RAIN GAUGE
Ropes Spring
SEWELL WELL
SCHULTZ TANK
Big Meadow
Burro Spring
LITTLE WELLS
LITTLE TANK
Salt Spring
Black Mountain
Lion Den Canyon
MOUNTAIN TANK
St. Nicholas Spring
Burke Spring
Ash Springs
Ash Canyon
Andres Peak
Goldenburg Springs
Cottonwood Spring
Chinch Bug Spring
Lead Camp Canyon
LEAD CAMP
Horse Springs
Lead Camp Spring
NEW WELL PASPALUM ENCLOSURE
NEW WELL
Crawford Spring
Mayberry Springs
San Andres Canyon
BROCK TANK
Block Mountain
1
2
5
6
9
10
11
1
12
3
4
8
2
13
14
7
LEGEND
Experimental Range Boundary
2 Pasture Number
Patented Holding
Good Motor Road
Poor Motor Road
Trail
Telephone Line
Pasture or Enclosure Fence
Pipe Line
House, Cabin or Other Building
Enclosure
Windmill
Water Storage (developed)
Ridge
Drainage
Spring
Vegetation Type Boundary

Figure 18. Proposed additional fencing for new pastures on Jornada for better management and proposed grazing management studies.

National Forest Administration has indicated from time to time that they need the information from more fundamental research on salting and distribution--and that most of the information we have now is largely theoretical. It remains to be determined, on an animal nutrition basis, whether or not in salting away from water cattle will do as well or better than when salted at water. To determine this, the experiment should be set up similarly to many animal husbandry studies, whereby an attempt is made to eliminate the pasture factor. Thus two pastures are selected as nearly alike as possible with regard to water, vegetation, and topography. Cattle at the beginning of the experiment are divided into two lots as nearly alike as possible on the basis of 3-day weighings, age, condition, etc. The check lot would be salted at water and the other lot away from water. Both pastures would be stocked conservatively. At the end of a time period of say 28 days, the cattle would be gathered and weighed, then changed as to pasture at the same time changing the method of salting within the pasture. In order to secure information on the range vegetation phase of the study, a system of panel plots would be required at different distances from water. These would be opened and closed in conjunction with the movement of the two herds. Such an experiment should cover a period of several years in order to secure sufficient data on weights of animals and production of calves. The results obtained should answer the cowman's questions, "Is salting away from water injurious to my cattle?" "Can I make as much or more money by doing so?"

There is need, too, to make comparisons on effect of water control--for example, closing off permanent waters when temporary tank water is available, testing aluminum pipe for supplying water to cattle thus encouraging use of outlying grass areas; and various fencing schemes for forcing the movement of cattle out from permanent water.

(3) Study of relative productivity of various range types: In connection with this study phase, stockmen have requested information as to the relative feeding value of black grama, tobosa and burrograss. Some contend that animals will gain more rapidly and will become heavier when summered on black grama than when grazed on green tobosa. Management plans on the Jornada provide that the black grama should be reserved for winter use, (and this is the ideal use from the standpoint of its growth requirements), and that grazing use be made of tobosa while it is green and palatable. This procedure will undoubtedly continue as the most effective over-all management plan, but we should be in a position to know the answer as to what it costs in terms of loss in weight and as to whether or not there is a place in the operation for utilizing some black grama range during the summer. To gain this information will require close coordination with the over-all management plan and careful balancing and sorting of cattle--possibly ear tagging to maintain identification and periodic weighing of all classes including calves, as determined by the growth stage of the vegetation. This study phase could be fitted into (1) above.

(4) Supplemental feeding: In 1922 Jardine and Forsling ( ) recommended that:

> "Plans for the future on the Jornada Range Reserve include selling the best steer calves in the fall to feeders in the corn belt, if possible, and feeding all young stock retained three-fourths to 1 pound of cottonseed cake per day for 90 to 120 days in the spring to keep them growing during this period. Results to date in feeding seem to justify such practice. With the increased cost of handling and producing stock in general every opportunity for

increasing the profit is worthy of consideration and trial."

This practice has been followed almost every year since 1938. The cooperator contends that it has been a worthwhile, economic practice even though from the nutritional level of the range forage cottonseed cake has been fed in excess of supplemental requirements. Since there have been no check lots of short yearlings without supplemental feed, it is not possible to determine to what extent supplemental feeding has increased animal weights at marketing time in the spring. Furthermore, there has been no follow through on the production from long yearlings (since they are sold in the spring) which might otherwise be carried through until October. Feeding has been done at water, which may or may not be the most desirable practice. Such information would be decidedly worthwhile and could be obtained with but little additional labor.

(5) Handling livestock: There are many phases of handling livestock that are worthy of investigation and which are warranted on the basis of the manner in which they may affect management plans. To mention a few--yearlong breeding vs. seasonal controlled (bulls are with cows yearlong on the Jornada); time of calving, which would require control of breeding (Mr. B. A. Christmas believes that he can make "a third more money" by calving in November and December and "caking" the cows during the winter); and production from the mountain pasture compared with the mesa.

All of these studies would require extra labor in handling cattle, which the cooperator may regard as excessive. How much this would amount to it is not possible to estimate now--but if it is a significant item, it should be possible to provide some sort of compensation for it that is satisfactory to both the cooperator and the Department. To follow study phase (1) effectively will require close cooperation from the College and the provision for a P1 or P2 technician. An additional man of similar grade would be required to carry out a well rounded attack on all phases (assuming that the Jornada work center area is provided with a P4 leader). These men would be in addition to the services of the present Superintendent.

SHORTGRASS PLAINS

Characteristics, scope and land values.--The shortgrass plains range province occupies most of western Texas, the Oklahoma panhandle and eastern New Mexico. Covering some 80 million acres it is the most important livestock area in the Southwest, supporting nearly 2 million head of cattle, 4½ million sheep and most of the mohair goats (see Table 4). The elevation of this province averages about 3500 feet. Average yearly precipitation is about 17 inches in most of the area but ranges from 14 to 22 inches. Most of this, in fact over 70 percent, occurs during the period April to September--permitting a good deal of dry land farming. Part of it is in the "dust bowl" region made famous with the drought of the early 30's.

The short grass range province as it occurs in the Southwest is an extension of the major plant formation of the same name in the Great Plains and is similar botannically. Principal forage species are: blue and sideoats grama, (Bouteloua gracilis, B. curtipendula), buffalo grass (Buchloe dactyloides), in the more humid portions, hairy triodia (Triodia pilosa), curlymesquite, threeawn grasses (Aristida spp.), alkali sacaton (Sporobolus airoides), small soapweed (Yucca glauca), and the low value ring grass (Muhlenbergia torreyi).

The shortgrass range province is ideal for year-round production of both cattle and sheep. Grazing capacity of shortgrass range in good condition varies from 20 to 60 acres with an average of about 45 acres per cow yearlong. Considerable areas have deteriorated, because of continued heavy grazing use, to snakeweed with only remnant grasses; other

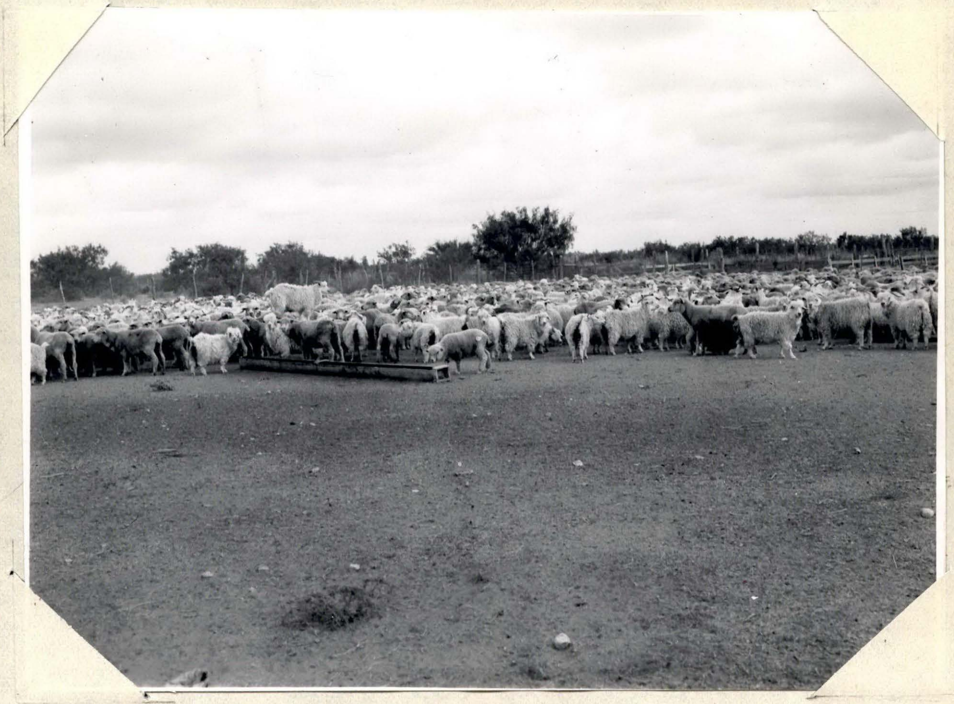

Figure 19.--Multiple yearlong use of range lands with cattle, sheep and goats is a common practice on much of the shortgrass range province in Texas. All three kinds of domestic livestock are grazed loose in fenced pastures--in this case the sheep and goats have been gathered for marketing the offspring. Multiple grazing use has been generally conducive to serious range deterioration.

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portions have become covered with dense stands of the low value sand sage (Artemisia filifolia), and shinnery oak (Quercus havardii), and the major portion of it is in various stages of invasion by mesquite. The more heavily infected areas are relatively poor in forage production even during years of favorable rainfall.

The climate is conducive to the yearlong grazing of livestock on the range. Aside from its value for agriculture other land values such as watersheds (in the sense of supplying irrigation water), timber, and wildlife are low in the shortgrass range province.

Review of past research.—The work of Bentley ( ) and Jared Smith ( ) in the late 1890's in western Texas has been previously cited. It will be recalled that these investigations described the deterioration, the problem of mesquite, and recommended various range improvement practices including rotation-deferred grazing, reseeding, furrowing and "scarification." The Bureau of Plant Industry has had work underway in grazing management studies at their Southern Great Plains field station at Woodward, Oklahoma, during the past 10 years. This work has been under the supervision of D. A. Savage and is confined principally to the effects of various systems and degrees of grazing use by steers. The work at this station has also included reseeding and the elimination of sand sage. Similar work has been underway at the Soil Conservation Service Experiment Station at Amarillo, Texas. The Bureau of Plant Industry has also, for a number of years, maintained a Field Station at Tucumcari, in cooperation with the New Mexico Agricultural Experiment Station, where they have undertaken a few studies of range reseeding. The Texas Agricultural Experiment Station, at its various sub-stations at Spur, Sonora, and Alpine, have maintained for a

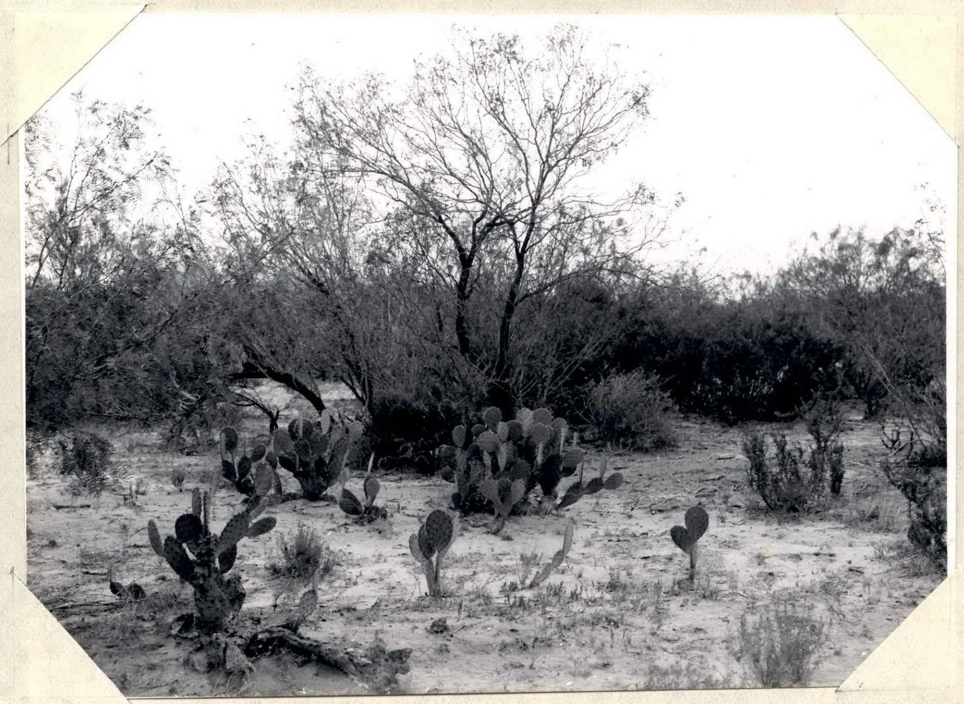

Figure 20.--Mesquite and prickly pear have encroached and increased in abundance on vast areas of the shortgrass range province. Photo taken near Del Rio, Texas.

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number of years studies in noxious plant control /bitterweed (Actinea odorata) and mesquite/ reseeding and poisonous plants (identification of toxic principles and control of losses). They have also intermittently undertaken work in grazing management. The Southwestern Station has never undertaken research work in this province--principally because of lack of funds.

Major range problems and future research to meet them.--Major range problems (at least in the southern half of the shortgrass range province) stem inlarge measure from dual or multiple use (cattle, sheep and goats, on same area), combined with continued and excessive grazing use. This kind of grazing use has undoubtedly greatly accelerated and in many instances initiated the invasion of low value plants such as mesquite,sand sagebrush and bitterweed.

The philosophy of "diversified ranching" was recommended by Youngblood and Cox (   ) in 1922 following an economic study of ranching on the Edwards Plateau country of Texas. Multiple grazing use, in theory has much to recommend it as a profitable ranching method but in practice it is difficult to adjust livestock numbers to the forage supply and consequently it has been conducive to much range deterioration in Texas. However, one method of dual use that the writer has seen in successful operation (Ray Willoughby Ranch near Alpine, Texas) involves operating on the basis of permanently stocking a small breeding herd of cattle yearlong with additional stocking at the end of the growth season in the fall with wether lambs in numbers varying with the size of the forage crop. The wethers are then sold in the spring before the onset of next summers growth. Wethers are not purchased during drought years.

Dual use has demonstrated that the herder system is not necessary for managing range sheep and that sheep can be most successfully grazed loose inside fenced pastures. Youngblood and Cox (   ) describe the advantages of multiple use in the following terms:

> "The cattle prefer the grass and some of the weeds such as the tallow weed. Sheep not only utilize the grass, but they also make a better utilization of the weed growth than either cattle or goats. Goats are apparently fond of most everything. They make a fairly good utilization of the grass and weeds, but seem to be fondest of browsing upon live-oak and other brush. Goats do better on the rough lands than any other type of livestock in part because they find their favorite foods there and in part because they are both venturesome and agile. They get around on the rocks and places where other livestock would not go and when necessary stand upon their hind legs and browse as high as they can reach.
>
> It follows that on the level land one may have considerable latitude in proportioning the number of cattle and sheep which he may run because cattle and sheep are rather strong competitors when it comes to utilizing the carrying capacity of the level ranges. All the goats that one needs to run on the level land is a sufficient number to hold the brush in check.
>
> The rolling lands offer the greatest opportunity for variations of proportions of cattle, sheep and goats without materially affecting the carrying capacity. There should be enough cattle to utilize the taller grasses and some of the weeds. There should be enough sheep to utilize the rest of the grass and weeds and there should be enough goats to hold the brush in check, but not enough to destroy it.
>
> On the rough range there is a limited carrying capacity for cattle, but it is not essential that more than just a few head be run. It is more important that some sheep be run in order to utilize the grasses and weeds. It is more important still to maintain a considerable proportion of goats on the range not only because they are naturally best adapted to the rough land, but also because there they ordinarily find the greatest amount of browsing."

Later in the same paper Youngblood and Cox conclude that "it will pay ranchmen to stock their ranges more conservatively in the future than they have in the past."

Figures are unavailable on present range condition and trend for the shortgrass range province. However, data collected by the Production and Marketing Administration in connection with their range program for 13 counties in eastern New Mexico are of interest. Condition and trend on 1446 ranch units were appraised in 1946 by the method described by Parker and Woodhead ( ). The work was done mostly by stockmen with a meager amount of training in judging condition. Out of the total of 1446 ranch units (information is confidential) 1.9 percent were appraised as in excellent condition, 55.2 percent as good, 39.8 percent as fair (unsatisfactory) and 3.0 percent as poor. On 66.2 percent the trend was considered as upward, 16.6 percent as static, and 17.2 percent as downward (deteriorating). Although these figures may be optimistic (necessarily so because of the lenient nature of making PMA benefit payments) they do indicate that over 40 percent of the range in eastern New Mexico is in unsatisfactory condition. It is doubtful if range conditions are better or worse in the other portion of the shortgrass range province. These figures alone indicate an urgent need for the Station to initiate range research work and develop guides for improvement.

A brief review of the major range problems and the steps which should be taken to yield information that will be materially helpful to stockmen in meeting them is set forth in the 1941 Annual Report of the Southwestern Station. From what little the writer has seen of the shortgrass range province these remarks on range problems and research that should be undertaken to provide the answers are sound and logical. The material in the 1941 Annual Report follows:

"The problem foremost in the minds of Texas operators is the invasion of woody species on many of their better range areas. In eastern Texas the principal invaders are species of oak and juniper, while in southern and western Texas mesquite is of paramount importance. As these invasions have been accompanied by material decreases in grazing capacity, many of the local residents are of the opinion that unless practical and economical means of control are developed, the range industry in Texas will be seriously affected.

Stockmen of Texas are also much interested in utilization standards and in determining the grazing capacities of their ranges. Because of high land values, they are vitally concerned with the economical production of livestock products and thus realize the great need for the most efficient method of range management.

Finally, a good proportion of the range land owners and operators are interested in range research, and their support can be counted on in the development of such a program. Because of the scarcity of Federal land in Texas, such a program possibly should be supported largely by the State. However, the State Experiment Station may find difficulty in obtaining additional State funds sufficient for a practical range research program and hence Federal participation will be needed to round out the necessary program. At the present time the demands from Texas cannot be adequately met by the Forest Service through its Southwestern Station. Insofar as conditions in Texas are similar to those on the experimental ranges, direct benefit can be derived by the people of Texas from the Station's past and present program. On the other hand no work has been done by the Station in Texas, and the present experimental ranges are not representative of the major portion of the Texas range lands. In order, therefore, to meet this situation, some expansion should be made eastward if the Southwestern Station is expected to be of greatest service to the State of Texas. Under existing conditions the needs of all concerned can be best met by: (a) the development and maintenance of close cooperative and working relations with the Texas Agricultural Experiment Station and Extension Service, and (b) through increased Federal appropriations for an extension of the Forest Service research work which would be directly beneficial to the stockmen of Texas.

Considering the great area and the potentialities of efficient and economical production of beef, mutton, wool, and mohair in Texas and at the same time the need to bring about restoration of the presently depleted ranges, the initiation of a systematic program of range research in that section and the formulation of means for the dissemination and application of new information on all phases of range management and maintenance through the existing facilities of the State Agricultural Experiment Station and State Extension Service are clearly in the interest of long-time national security."

In order to begin range research work in the shortgrass range province and to effectively plan for it, it is suggested that a P4 or P5 grade technician be assigned to the area to make a thorough going problem analysis of the range problems and needs. This job would require six months to one may year and should, if possible, precede the establishment of a work center.

FOREST RANGE

Forest range has many values, including water, timber, wildlife and range. Its importance as watershed exceeds all other land values. This does not mean that other uses should be excluded but they must in many instances be subordinated to and in all cases properly co-ordinated with the use of the land for watershed. The present economy and future agricultural and industrial development of both New Mexico and Arizona are largely dependent upon attaining and keeping these lands in satisfactory condition. "Forest Range" includes two distinct but interdependent range provinces, the ponderosa pine-bunchgrass and the woodland. Consequently discussion of these two provinces will be made more or less concurrently.

In the mind of the general public the Southwest is generally thought of as largely treeless; yet the total forest area exceeds 51 million acres. This is an area larger than the State of Washington. In more exact terms the total forest area is 39,539,000 acres comprised of 10,739,000 acres of sawtimber forests (about 60% commercial) largely ponderosa pine and about 29 million acres of woodland mostly pinyon pine and juniper. The remainder of these two provinces is made up primarily of short grass range. In view of the recent rapid growth in southwestern urban communities, requiring large quantities of lumber for homes and wood-using industries, timber is an important forest product. The annual cut is about 275 million board feet valued at more than 17 million dollars. Most of this is carried out on a sustained yield basis. Nearly all of the forest area is grazed at some time during the year by domestic livestock. Exact figures on the number of animals grazing forested lands are not available but these areas unquestionably contribute an important part of of the range forage necessary for maintaining the livestock population. A conservative estimate would place the numbers of livestock grazing forested lands at 350 thousand for cattle, 900 thousand for sheep, and 200 thousand for goats.

In the woodland areas most cattle outfits are operated on a cow-calf basis. In the higher summer ranges steer operations are common. Sheep are grazed on both types of range with the bulk of the lambs going as grass-fat to market in the fall from the better managed outfits. Animals are usually marketed in the fall going to irrigated pastures, feed lots, or direct to slaughter.

Ponderosa Pine-Bunchgrass--Characteristics, Land Values and Problems.--Sawtimber forests, including ponderosa pine, spruce, and Douglas fir, are distributed chiefly through the north and central portions of Arizona and north and west central New Mexico. They form the principal plant formation on high plateaus and mountain slopes varying in elevation from 6,500 or 7,000 feet up to 11,500 feet. Annual precipitation varies from 20 to 30 inches. (See table 4). The important forage plants in open ponderosa pine forests are: Arizona fescue (*Festuca arizonica*), mountain muhly (*Muhlenbergia montana*), pine dropseed (*Blepharoneuron tricholepis*), Thurber's fescue (*Festuca thurberi*), muttongrass (*Poa fendleriana*), blue grama (*Bouteloua gracilis*), blue grasses (*Poa* spp.), bromegrasses (*Bromus* spp.), and a variety of weed and browse species. Depending on elevation the grazing season usually covers a period of about 5 months from May to October. Grazing capacity varies with the density of the timber stand and with range condition. Dense stands of

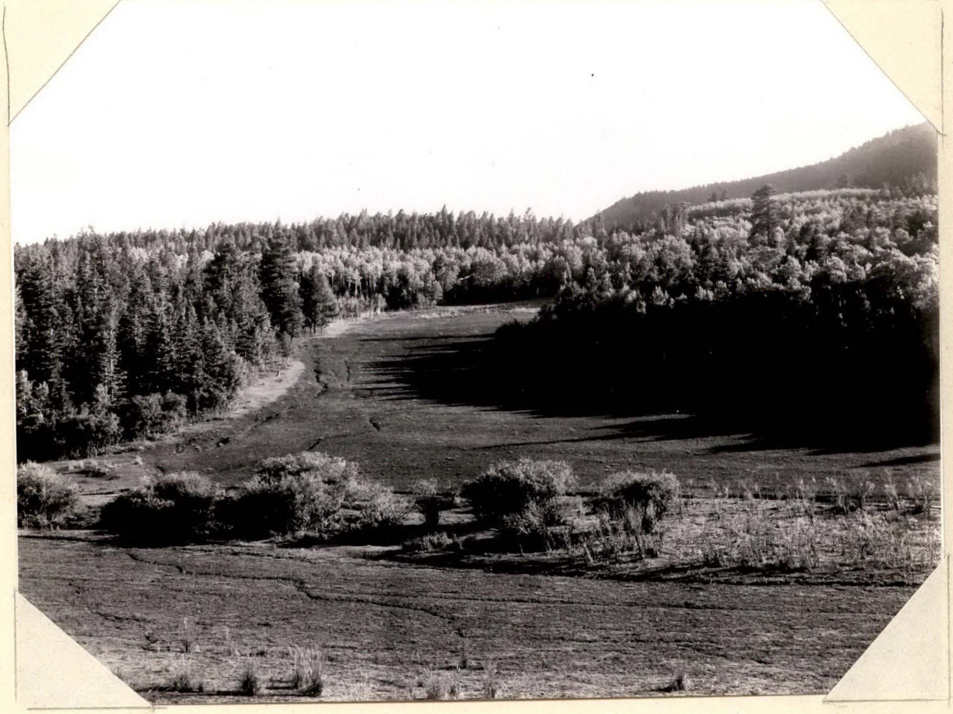

Figure 21.--Many openings and meadows in the high forest ranges are in poor condition. In this case deterioration has resulted from dry farming (now abandoned--Carson N.F. New Mexico). These lands form important parts of high value watersheds.

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timber are considered unusable. In the more open areas of pine bunchgrass range, in good condition with gentle topography, grazing capacity is about 2 to 4 acres per cow per month whereas on comparable range in poor condition 10 to 20 or more acres per animal unit month are required.

Overshadowing the importance of all other forest land uses is the watershed value. Each year winter snows and rains furnish the bulk of the water flowing into the great irrigation projects of the Elephant Butte, Salt River and Gila.

The degree and manner of livestock grazing use bears an immediate and important relationship to surface water run-off, soil erosion rates, sedimentation, flood hazards, timber reproduction, wildlife conservation, recreation, and other land uses.

The agricultural economy of the Southwest, particularly Arizona and New Mexico, is based largely on irrigated agriculture and range livestock, although there are areas of successful dry farming in northern Arizona and eastern New Mexico. This economy in general depends on a pattern of land relationships wherein comparatively small areas of water-consuming lands are directly dependent on extensive tracts of water-yielding forest lands. The irrigated lands are located in the lower, drier portions of the main valleys and drainage basins and are far removed from the watersheds. Consequently, public recognition of the importance of keeping the water-producing lands in good condition is not only largely lacking but difficult to attain. In general there is a distinct occupational difference between farmers and ranchers although this is not so marked in central Arizona where there are many individuals who farm as well as operate mountain or mesa ranches. In the sheep industry of Arizona there is a seasonal migrational pattern of moving bands from irrigated winter pastures to the higher summer forest ranges. But the philosophy of grazing use in maintaining a "tin-roof watershed" is common. The future agricultural prosperity of the region will depend directly on how well the range watershed lands are managed and how rapidly conservation practices are adopted.

Water is so important to the economy of the Southwest that it is difficult and in some ways meaningless to attach an economic value to it. Nevertheless, the value of the watershed lands has been estimated in several ways. For example, the drainage areas of the Salt and Verde are worth $15.22 an acre if based on the water yield alone and $108 an acre if computed on the basis of crop values. (Capitalized at 3 percent). The same lands have an average market value of about $2 an acre for range. This does not mean that these lands should not serve both as range and watersheds--although there are some lands which because of steepness of topography or erosibility of soils should not be grazed (such lands should not be termed "range"). However, if the vegetational cover is impaired both range and watershed values suffer. Grazing use should be so designed as to secure and maintain the highest production of range forage that is commensurate with other land values. In other words, proper range and livestock management will encourage the establishment and maintenance of desirable forage plants, promote plant vigor, and provide the highest type of erosion controlling plant cover.

In the Southwest the conflict between timber production and grazing depends largely on the kind of range management practiced including season of use and proper distribution of livestock through better watering and salting facilities. Damage where it occurs consists mainly in browsing

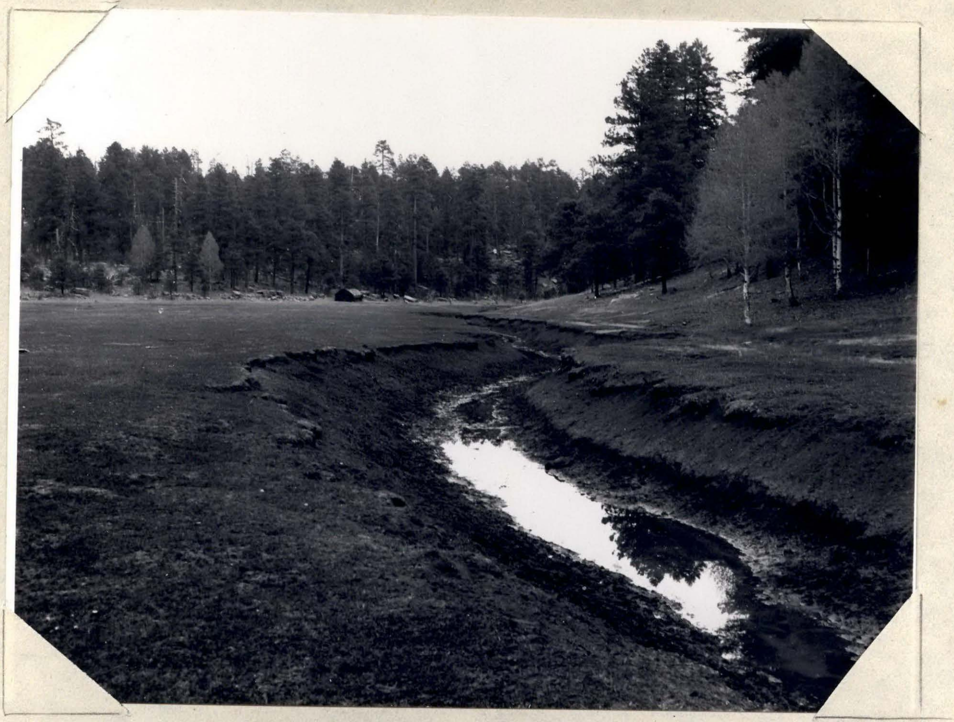

Figure 22.--The ponderosa pine-bunchgrass range province has many land values--water, timber, recreation, wildlife and range. Misuse lowers all values. (Sitgreaves National Forest, Arizona).

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the terminal leaders of young coniferous tree reproduction especially during dry periods in spring and again late in the fall when needle leafage may be eaten. Such grazing either retards growth or causes actual death loss of small seedling trees. In dense stands of timber this is not serious because the density of the trees alone prevents much grazing use and forage values are generally low.

In the more open forest areas, however, where grazing use by livestock or big game has been excessive, timber values have suffered. In the woodland areas including savannah, excessive grazing use has served to encourage and accelerate tree reproduction. Curiously enough the renowned 1919 seedling year in the ponderosa pine type coincided with heavy grazing use occasioned by the heavy stocking that took place during World War I and then was followed by several years of livestock reductions.

The animal life of the forest, the fish and birds, and even domestic livestock is a prime essential to enjoyable public recreation. In the Southwest ever increasing thousands of people--hunters, fishermen, campers, vacationists and health seekers find enjoyable recreation on forest land. Consequently, wildlife should be efficiently produced and wisely used.

Grazing use as it bears on wildlife and recreation may become in serious conflict. Destructive grazing destroys the habitat of desirable wildlife, results in muddied streams, and water temperatures become ill suited for fish. This in turn means poor hunting, poor fishing, and unenjoyable recreation. Excessive numbers of big game or livestock or even game fish mean inefficient production. On most of the open timber types in the Southwest there is little or no conflict between game and domestic livestock. In some areas, particularly on the lower woodland ranges, there is competition for forage during winter by cattle and deer. There are also a few areas (i.e. Sitgreaves) where livestock and elk have come into conflict within recent years.

For many years in northern New Mexico the demands on the range resource in both woodland and ponderosa pine range provinces have been excessive and consequently grazing use has been intense. For example, on the Carson and Santa Fe National Forests the average paid permit is for about 12 head, with larger permit up to 100 head of cattle or a few more. Because of the characteristically large families involved, even the larger permits may be uneconomic. There is also a good deal of livestock in continual trespass. Excessive grazing use prevails and range conditions on the whole are not satisfactory. The value of these lands for watershed purposes greatly exceeds all other values and directly affects the welfare of thousands of water users in the lands below. Population is in excess of the land resources, at least under the present system of use. New industries are needed such as those which will make full use of wood into manufactured articles. The present important tourist attraction will have to be carefully developed to avoid commercialism. The problem of improving and protecting these lands is complex because of the several aspects involved--watersheds, timber range, and sociological. The problem is so intense and affects so many people that an entire work center is fully warranted and as such is given first priority by the Station in in its estimates of future financial needs.

Woodlands--Characteristics, land values and problems.—The woodland ranges lie immediately below the ponderosa pine forests and range downward to about 4,500 feet in altitude. Annual rainfall varies from 12 to 18 inches and the main growing season for perennial grasses is during July, August, and September. The forest is composed chiefly of pinyon pine (*Pinus edulis*) and juniper (*Juniperus* spp.) with evergreen oaks (*Quercus* spp.) predominating in the southern portion of the region. Interspersed throughout the type are open grama grasslands and savannah. The principal forage plants are: blue grama, sideoats grama (*Bouteloua curtipendula*), black grama (*B. eriopoda*), hairy grama (*B. hirsuta*), bluestem wheatgrass (*Agropyron smithi*), galleta (*Hilaria jamesi*), curlymesquite (*Hilaria belangeri*), muttongrass (*Poa fendleriana*) and Indian ricegrass (*Oryzopsis hymenoides*). Browse species include: mountain mahogany (*Cercocarpus* spp.), cliffrose (*Cowania stransburiana*), ceanothus (*Ceanothus* spp.), eriogonum (*Erigonum* spp), and rough menodora (*Menodora scabra*). In central Arizona a true chaparral community made up primarily of shrub live oak (*Quercus turbinella*), sumac (*Rhus trilobata*, *R. ovata*), and the browse species mentioned above covers some five million acres. The woodland range is used on a yearlong basis by cattle or sheep but is occasionally reserved for winter grazing. Dual use is not common. Even on ranges in satisfactory condition grazing capacity is relatively low, varying from 3 to 10 or more acres per cow per month. The forage of grama ranges has long been reputed to cure well for winter grazing. Recent research indicates that this is not generally true but that in the winter period the protein level and phosphorus content of the forage grasses falls below the nutritional requirements of livestock. Unless palatable browse, that will supply these deficiencies, is plentiful, the feeding of supplements such as cottonseed cake on the range is especially advisable during the winter for maintenance of top livestock production.

In comparison with thehigher open forest range watershed, woodlands yield relatively little water but are important potential sources of sediment. Prior to the introduction of domestic livestock most of the dense stands of pinyon-juniper were confined to rocky ridges and poor shallow soils or occurred as savannah on the better sites. During the past half century these trees, especially the junipers, have encroached on the better soils of the adjacent grasslands. Then too, reproduction has filled in the openings between the mature juniper trees of the savannah forming a nearly continuous woodland canopy. These invasions are still in progress and have been attributed to two causes: grazing and protection from fire. They unquestionably have been accelerated by continuous heavy yearlong grazing use. Other plants of low forage value such as rabbitbrush (Chrysothamnus spp.), pingue (Actinea richardsoni) and snakeweed (Gutierrezia spp.), have also increased in abundance largely because of excessive grazing use. The impact on the economy of the region, at least where these invasions have been accompanied by over use, is twofold--first through lowered forage crops animal production is decreased, and second, with the replacement of the original perennial grass cover with woody or taprooted herbaceous species the erosion rate has been accelerated above the normal.

Granitic soils, derived from granite and related rocks are characteristic of much of the chaparral and other woodland areas. These soils are naturally highly erosive and a prime contributor of sediment. Once deterioration is initiated it is exceedingly difficult to check the unraveling process because natural recovery of the vegetation is inherently slow in this type. Research is needed on management (many contend that grazing use cannot be made on these soils without pulling the trigger to accelerated erosion) reseeding, including mulching, and noxious plant control in order to devise satisfactory guides to improvement.

In the woodland areas where juniper has encroached on adjacent grasslands control of invasion through elimination of tree seedlings would appear to be warranted on the basis of increased forage and maintaining the most effective erosion control plant cover. In the saw timber forests the case is not quite so clear. Increase in tree reproduction has resulted in crowding out the forage plants through shade and competition for moisture. This is unfortunate to the interests of grazing but is as it should be on the lands where timber is the primary value. In many cases, however, it has meant the closing in of natural openings within the forest—valuable not only for grazing but as natural firebreaks. It would seem sound land management to keep these openings in grass and maintain them as firebreaks for protection of adjacent forest lands. After all, grazing if properly conducted may be a distinct aid to timber production. On most forest ranges in the Southwest it is believed that grazing can be fitted into timber harvesting and that both can be carried out successfully together on the same area, i.e., cutover areas, at least until restocked. It remains for research to uncover the facts.

Grazing and watershed problems in the forested range stem largely from excessive stocking combined with the effects of recurrent drought. The parts of the summer range which are largely in the open timber type are in fair to good condition. On the other hand, most of the meadows and natural openings are in varying degrees of deterioration. The woodland areas, the bulk of which are grazed on a yearlong basis, are on the whole in unsatisfactory condition. McArdle et al (   ) in 1935 reported for

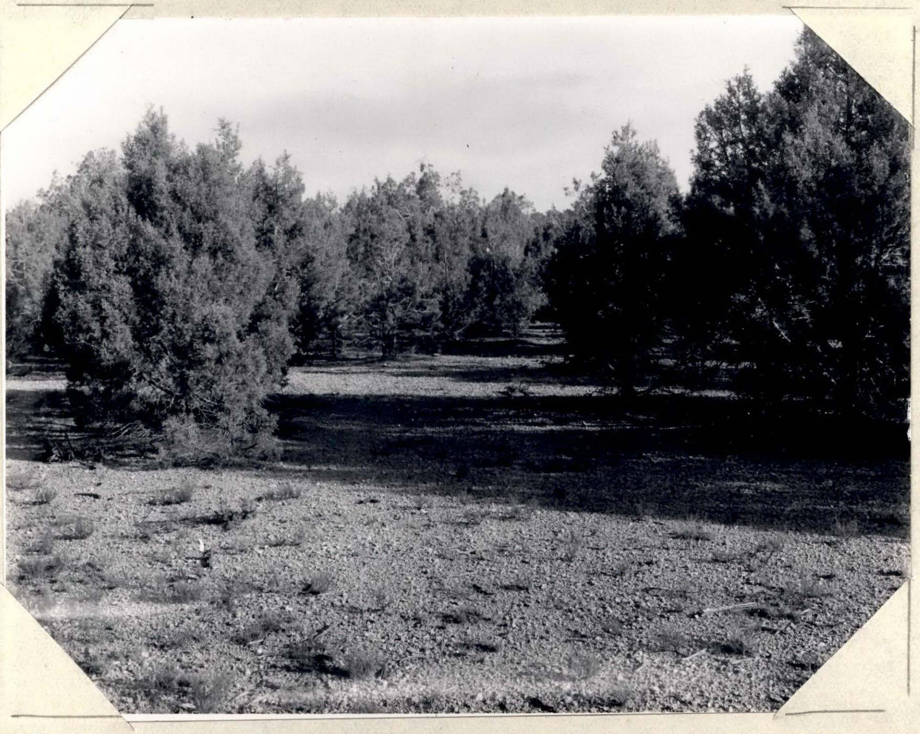

Figure 23.--Juniper has encroached on grassland areas in much of the woodland range province. Watershed and range forage values are affected.

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the pinyon-juniper type in the west (mainly of value for forage in Arizona, New Mexico and southern Colorado) that on two-thirds of this type the forage is either materially or severely depleted, and on an additional fourth it is extremely depleted. This is probably still about as fair an estimate as can be made although there has been some improvement--for example, on some national forest allotments. In the portions of the range in unsatisfactory condition forage production is low, even in years of good rainfall and in spite of a fair sod of blue grama. This is largely because of poor plant vigor and an inadequate carry-over of grass litter which is necessary for maximum moisture infiltration and soil fertility. In the areas of juniper invasion range condition and livestock production are in a downward swing. Deterioration of the forest range lands not only results in lowered grazing values but through accelerated erosion and movement of sediment shortens the life of reservoirs and causes stream beds to aggradate. This in turn creates drainage and flood control problems as are found along the Rio Grande.

As pointed out by Arnold in his present problem analysis, the woodland type is the key to proper balancing of livestock numbers because if these lands were properly stocked, managed, and improved by reseeding and noxious plant control they would materially ease the grazing pressure on much of the higher summer forest lands. The bulk of forage crop is produced during the summer months and late fall is the main marketing period. Hence the range operator can estimate at this time the proper number to graze for the winter season, or on yearlong range determine the number to be grazed until the next summer's growth period.

Range research, past and present.--Published findings of research in grazing management for the forest range provinces in the Southwest is meager. C. H. Cooperrider and H. O. Cassidy spent many years studying the problem of injury to ponderosa pine reproduction from grazing use by livestock. Because of various controversial portions these data have been largely locked up, for the past few years, in the files--including a rough draft manuscript on their principal findings. However, Cassidy ( ) ( ) did report a few of the highlights of the research on how cattle and sheep may graze cut-over ponderosa pine-bunchgrass ranges with a minimum of injury to reproduction. An excellent technical paper on the recovery processes of ponderosa pine reproduction following injury to young annual growth was also presented by Cooperrider ( ). Proper utilization of bunchgrass range was reported by Crafts ( ), and in other Southwestern Forest and Range Experimental Station research notes (#25, 32, 36, 44) for woodland as well as ponderosa pine range species. Factors (i.e. distance from water, steepness of slopes, character of terrain, amount of timber reproduction, range condition and floristic composition of vegetation) that affect cattle use of ponderosa pine ranges in northern Arizona were reported by Glendening ( ) in 1944. This later work was so intensely done (with hundreds of randomized transects, covering several allotments) and the information obtained so useful to range administrators that it should be published in a more lasting form than in its present mimeographed release. The problem of juniper in the grasslands contiguous to and intermingled with the woodland range and the meager amount of research on its control was reported by Parker ( ) in 1945. About the only formal publication in grazing management that pertains directly to the forest range provinces is that prepared in 1919 by Chapline (   ) on the management of mohair goats. Although this work is now nearly 30 years old, the management principles outlined therein on the whold are still sound. Unfortunately, however, the raising of goats in the forest range provinces of Arizona and New Mexico is a rapidly decadent industry--so much so that at the present time there is little demand for information on the management of goats in these areas. There is need, however, for similar investigation in the shortgrass range province.

Present research in grazing management is confined largely to the efforts of one technician of P3 grade (J. F. Arnold) located at the Fort Valley work center for northern Arizona. He is now completing his second year of work largely in: Becoming familiar with the area and its problems, reviewing past research and gleaning what he can from the files in anticipation of publishing worthwhile material; and preparing a problem analysis and working plan for guiding future research.

Proposed future range research.--In planning any future research for the forest range provinces the needs of National Forest Administration should be given especial weight and consideration, because of their size and importance. The National Forests, because of the many land values and interests involved are administered under the policy of multiple use. That is each use is evaluated and accordingly integrated with other uses. Because of the varied interests involved the problem of administration is often complex and difficult. Research could be an assistance in formulating standards for classifying land as it is best used in theinterests of the region as a whole. Possibly the range condition criteria project will

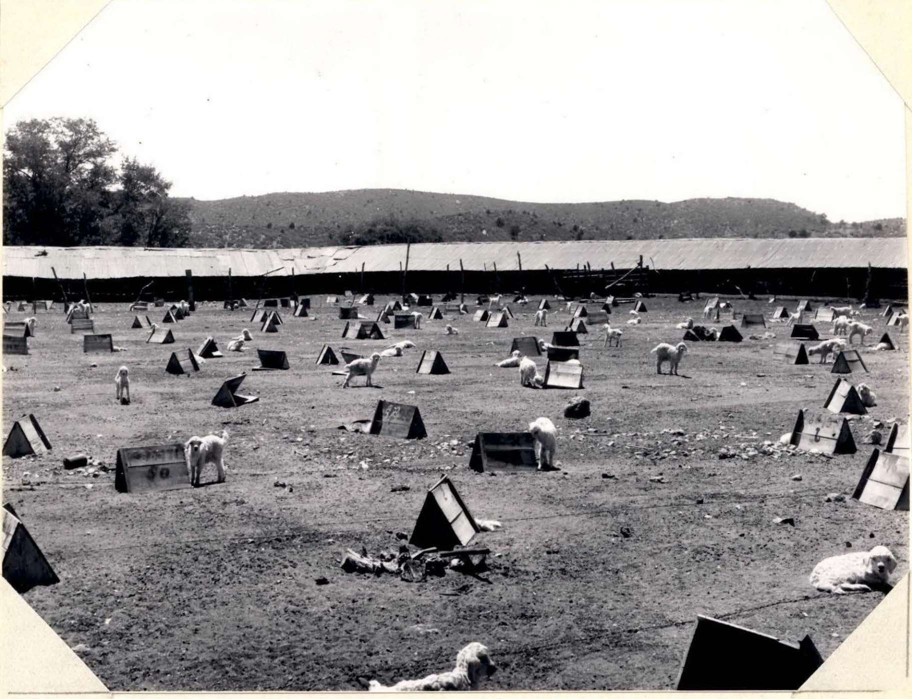

Figure 24.--Mohair goat production in Arizona and New Mexico is a decadent industry--perhaps it will recover with the adoption of new management methods requiring less labor. Photo shows toggled kids awaiting the return of their mothers from the range.

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supply some of the needed information.

The Region's research needs for the immediate future were expressed by A. A. McCutcheon at the 1945 Southwestern Station's annual meeting as follows:

> "(1) Continuation of the criteria studies on other range types similar to that just being finished for the Woodland type.
> If there is any way possible, we should like to see this work accelerated. This we recognize is dependent upon forthcoming appropriations and manpower. Guides or measures as to what composition, density, and vigor of the vegetation should be for the different types would probably do more toward building up a true concept of conservative range use than any other single factor.
>
> (2) Utilization. The development of a simple, practical system of measurement, and a determination of just how much grazing different species will stand.
>
> (3) More fundamental research on salting and distribution. Most of the information we have now is quite theoretical.
> For years Forest Officers have been struggling with the distribution problem with little visible success. It is my belief that most administrators have been trying to force cattle to use range they simply won't use until the accessible feed has been grubbed to the grass roots. What degree slopes, for example, should we not expect cattle to use under any circumstances?
>
> (4) We know very little about the management of brush (chaparral) ranges. Whenever administrative action becomes necessary, it has to be based upon judgment. Facts instead of judgment would put the administrator on sure and safer ground. I do not know whether this should be a management study. Possibly a criteria study would give us what we need.
>
> (5) We should like to see at least two demonstrational allotments set up on national forest ranges, one on yearlong, and the other on seasonal range.
>
> (6) Continuation of the cooperative work on range reseeding on the same basis as last year.
>
> (7) Establishment of plots and line transects on a more comprehensive scale than in the past, as suggested by the integrating inspectors (Loveridge and Cliff), for the purpose of having factual information to support administrative action.
>
> (8) Juniper eradication in an experimental and trial sort of way, although until we get conservative use cattle grazing on

> the National Forests is simply extending the range of the species by creating favorable conditions for natural regeneration."

Administration has during the past year added another "need" to this list and that is for information on the effects of reproduction on grazing capacity in both the ponderosa pine and woodland range provinces.

To undertake a program of work which will fulfill these needs effectively would require intensification of present work in the northern Arizona work center and the undertaking of work at the proposed new work center for northern New Mexico. Some phases of the work are now being provided for namely: reseeding, and noxious plant control. The salting and distribution phases have been previously discussed in connection with work at the Jornada. Minimum requirements for fulfilling the grazing management needs would be somewhat as follows:

Range condition criteria	— one man year (P3 grade) for 5 years;
Utilization	— one man year (P3 grade) for 5 years;
Management of brush ranges and demonstrational allotments	— one man year (P3 grade) for 10 years;
Plot and line transect work	— two man years (P3 and P2) per year continuing indefinitely.
Effect of timber reproduction on grazing capacity	— one man year (P3 grade) for 5 years.

In the undertaking of any research work in the forest range provinces it should be kept in mind that the woodland type is the key to the range problems in that if these lands are properly managed and improved they will materially ease the grazing pressure on the higher ponderosa pine-bunchgrass ranges.

SUMMARY OF RANGE PROBLEMS AND RESEARCH NEEDS

We have touched upon the overall range problems in the Southwest and what has been done and what is now being done to uncover the facts necessary to meet them. The statement is often made that if we would only apply the knowledge we now have no further research would be necessary. It is true that if we could put into action our present knowledge much improvement would result. This does not lessen in any degree the need for future research. In fact, the more we learn of the biological complex with which we are dealing the more we realize how little we actually know. Furthermore we must not become so interested in the protection of the land resources from deterioration that we forget the people who use them. Then too, we often hear the question "Why bother?" This is best answered in the following:

> "....People live, pay taxes and die, as they have for centuries, without government programs; and in the Intermountain West, the resources deteriorate. If no more were done, the people would continue to live, pay taxes and die; and the resources would continue to deteriorate....at an accelerated pace.
>
> But to be content with what we have when it can be improved is an inadequate viewpoint. It is out of line with an enlightened social spirit--with economic thinking--with our defense efforts--with our desire to secure the strength and happiness of the nation and its citizens by protecting our resources of land and water for the support of those who will be the nation of the future.
>
> All these are human factors, rightly. That is the basis for advocating improvement in the use, management and control of land, forests, grass, and water with which people here make their living."

Summarization of the varied problems and research needs peculiar to each of the six major range provinces is difficult. Formulation of a research attack wherein first things come first is doubly difficult.

However, there are a number of major range problems of over-all importance which appear to stand out above all others, when one considers the history of grazing use and the causes and effects of range deterioration, and which will bear further discussion.

It has been pointed out that in the Southwest the bulk of the land is unsuited for cultivated crops, that the major use of vast areas of this land will probably always remain in the production of meat and other animal products from the forage, that on other areas (i.e. forest range) production of water is uppermost, and that the land may have many other values aside from grazing. We have seen that subsequent to the use of these lands for grazing by domestic livestock marked changes in the vegetation, native fauna, erosion rates, soil moisture relationships, and stream flow characteristics have occurred. The problem of excessive grazing use in the Southwest is largely the result of: (1) over optimism as to the grazing capacity; (2) the mild open winters have permitted year-long grazing use (except in the pine type) and consequently there has been failure to adopt management plans and a rate of stocking suited to the soils, climate, and vegetation; (3) failure to recognize changes in range condition; (4) tencency to hold over animals and gamble with the weather in the hope of a wet spring and new green forage; (5) tendency to think in terms of numbers (a carry-over from past marketing methods) rather than in terms of pounds of meat production; (6) failure to recognize the nutritional requirements of range livestock which results in practices such as holding over on summer ranges as long as weather permits, and in spite of declining weight gains; (7) laxity or hesitancy on part of public agencies (applies to government lands) to make needed adjustments because of the problem in human relations involved. It is unfortunate that these beliefs and practices have prevailed in the past and are even common today in the philosophy of some stockmen and some public range administrators.

Progress on the extension of research findings to actual adoption and practice by stockmen has been made during the past decade. To the research worker this progress has appeared irritatingly slow but when one remembers that the livestock industry is really less than 100 years old in the Southwest and that research workers themselves have often fallen down in publishing their findings and are so in part to blame, there is room for much hope in the future for conservation of the range resource.

The problem of range deterioration is serious in each of the major range provinces in the Southwest. The effects of excessive grazing use, fire, and cultivation of lands unsuited to farming are often spectacular. The many mountain meadows and mesa flood flats now incised with sharp sided erosion scars bear witness to this, likewise the many millions of acres of formerly open grasslands now covered with low value weeds and shrubs. But on the bulk of the range area the damage that has been done in the form of changes in the vegetation cover, and accelerated erosion rates is not irreparable. If it were there would be little hope or promise of improvement and conservation of the range resource and in turn there would be little need for range research.

The problem of improper balance between livestock numbers and forage supply throughout the Southwest is greatly complicated by the extreme fluctuations in yearly forage crops caused by variations in rainfall. It is important to the ranch operator that numbers be correctly balanced both from the standpoint of his pocketbook and the ultimate permanence of his business. In the regional and national economy proper balancing of livestock numbers with feed and forage supplies is necessary for conservation of the range resource. It is also necessary in times like these when meat is at a premium—a prime essential for national welfare and even world peace.

And yet each year large amounts of range forage are wasted through the maintenace of nonproductive animals. Whenever animals eat their fill every day in all seasons, about 70 percent of the digestible nutrients is required for body maintenance and the remaining 30 percent is available for growth and production of offspring. Under such conditions the mature beef cow, for example, will, year in and year out, weigh about 1,000 pounds or more, produce 80 to 90 percent calf crops, with calves weighing 400 to 450 pounds at 8 months of age. On the other hand, if the mother cows had been allowed only 70 percent of a full ration they would produce only about 50 percent calf crops averaging 320 pounds per calf. The latter figure represents about the long-time average for the Southwest and is significant in that it indicates that nearly half the cow population is being grazed on a maintenance basis with no production. Other factors such as the use of purebred bulls and culling shy breeders are important in animal production but overshadowing these is the matter of keeping animals in balance with the forage supply. This has been shown by the results of a long-time study at the Santa Rita Experimental Range in southern Arizona, the Jornada Experimental Range in southern New Mexico,

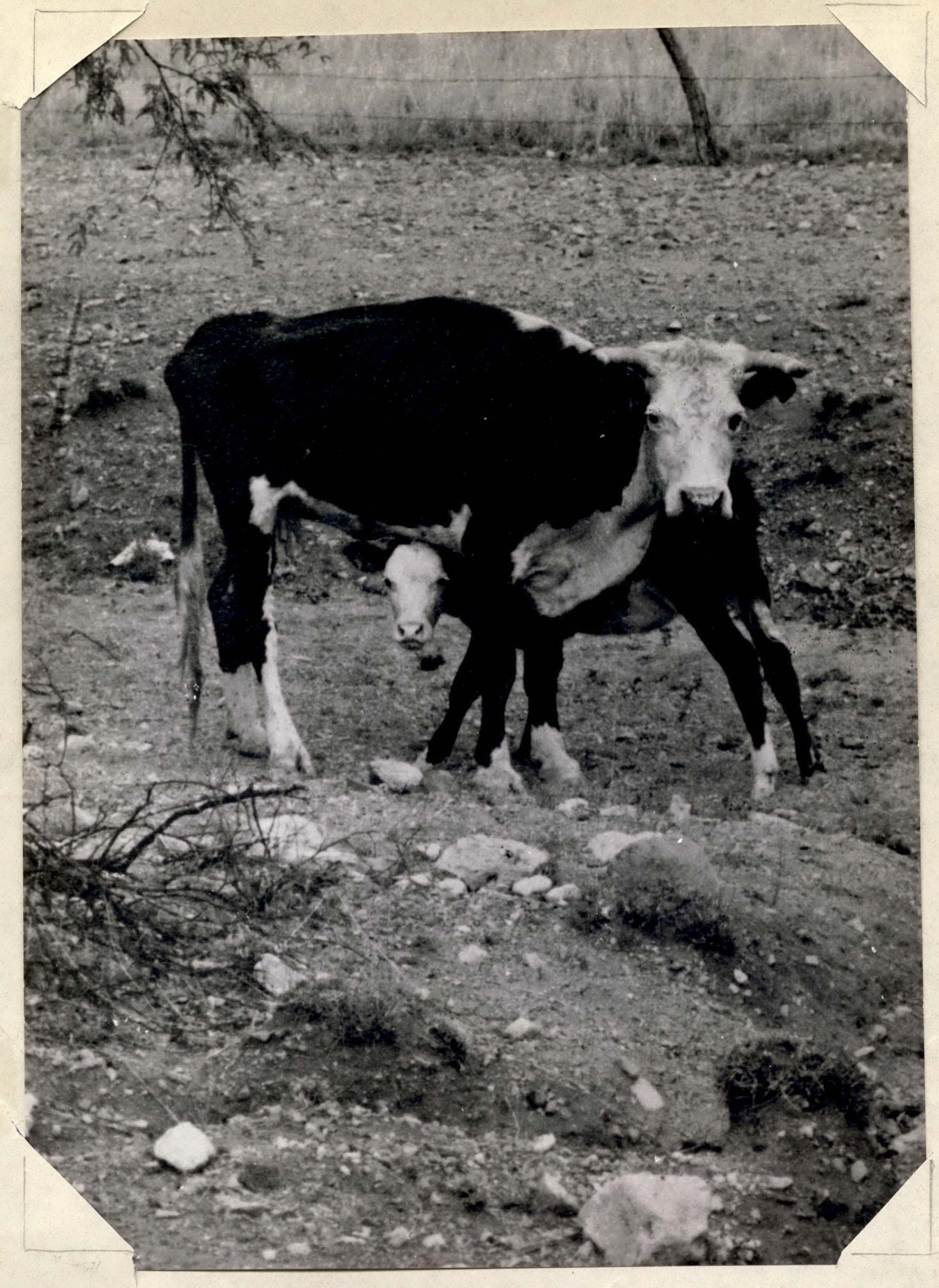

Figure 25a.--Grazing too many livestock is wasteful of range forage and destructive to the range resource. A 750 lb. cow--she probably won't calve next year and the range won't produce its potential maximum--witness the possibilities behind the fence. (see next page)

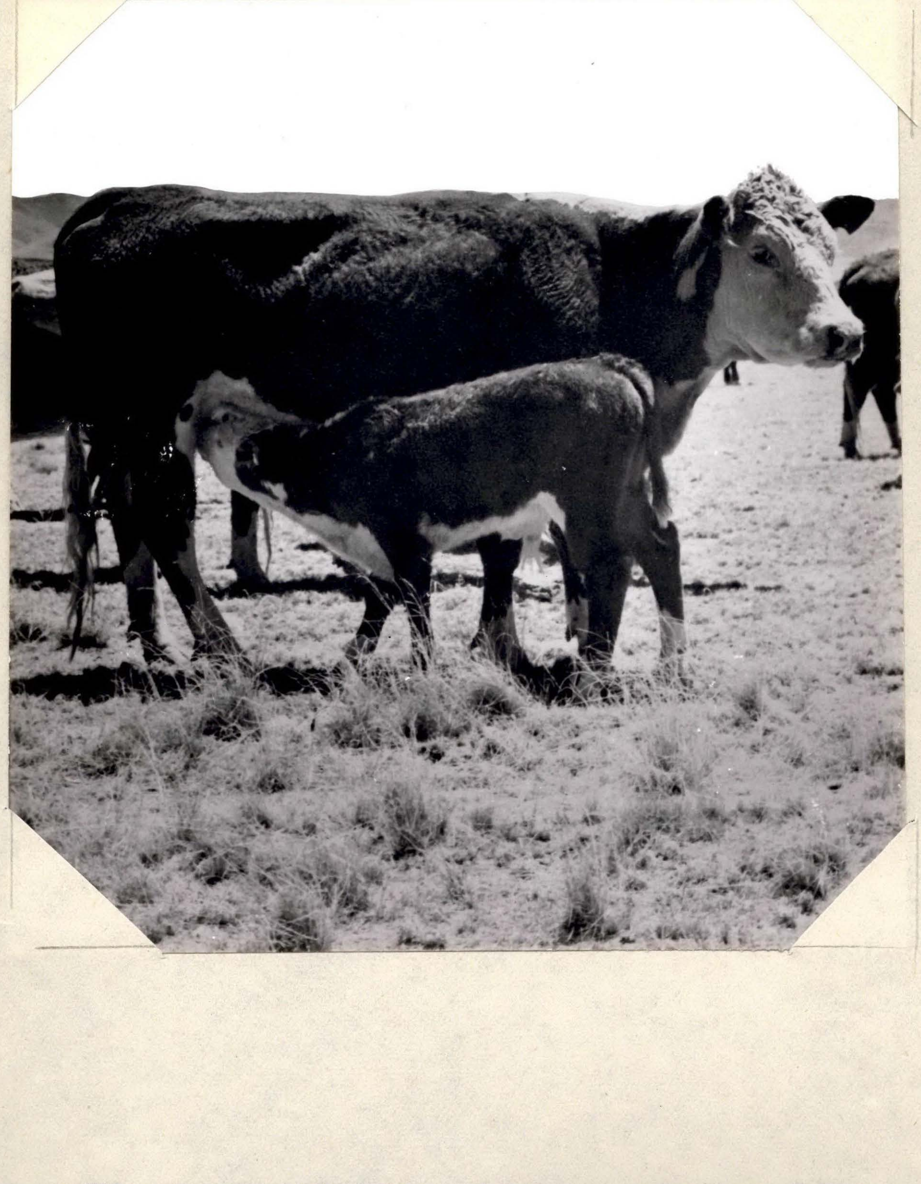

Figure 25b.--Provinding adequate forage every day of the year results in healthy productive livestock and insures the conservation of land values. A 1,000 lb. cow--undoubtedly she will calve regularly. This is the goa~~d~~l of range conservation.

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and is being demonstrated on the better operated ranches in the Southwest but intensive research is needed to really tie down the economics of grazing use and spell out the criteria for judging range condition and trend.

In the open pine forest range province proper balancing of numbers with forage supply is difficult because the animals start grazing this type in the late spring prior to the onset of the main summer growth season. If drought occurs they must either overuse the timber type or return earlier than usual to their winter range, which means an added burden on the latter unless numbers are drastically reduced during fall marketing.

On the portions of all range provinces in unsatisfactory condition the bit est job of revegetation can be accomplished through proper stocking and management. This is especially true where the range is not too seriously deteriorated and the key forage species remain in sufficient abundance to respond to management. In most instances this will simply mean bringing down livestock numbers to grazing capacity and securing good distribution of the grazing animals. Proper management, especially on the yearlong ranges, will apparently require additional cross fencing in order to periodically rest the more critical portions of the range during the growth season. Such fencing is also necessary for improved animal husbandry practices such as seasonal breeding and segregation of yearling heifers from bulls. Cross fencing large range units into pastures also tends to focus the attention of the operator on areas in poor condition which previously would have been unnoticed. In recent years in New Mexico "wolf-proof" fencing of ranges used by sheep, abandoning the herder system and turning the animals loose has been meeting with increased favor. Reduced costs and better management appear to result. Information is needed on all these points to sell them to stockmen and range administrators.

There are many areas in all range provinces where natural revegetation through management or even total protection from livestock grazing is too slow or uncertain. These are the areas where the original plant cover is largely gone and the fertile topsoil has become worn thin. These areas often form not only important parts of the range but exert great influence on the character and kind of run-off. In such cases range reseeding will no doubt have to be resorted to. Research and experience are just beginning to point the way to effective accomplishment. Reseeding offers possibilities for improving range conditions and increasing livestock production on both the open forest type and woodland range. If properly accomplished and accompanied by better stocking and management practice, it will provide more adequate forage, permit the adoption of proper grazing dates, alleviate grazing pressure within areas in critical condition and, by extending the "green feed" period, raise the plane of nutrition for game as well as domestic grazing animals.

One of the most serious and perplexing problems on forest range in the Southwest is the invasion of low value shrubs and trees; mesquite and juniper, for example, are the most persistent throughout much of the region and sagebrush is a common problem in the northern desert range provinces. Among the most troublesome poisonous plants are locoweed, pingue, whorled milkweed, and wild tobacco which each year cause reduced animal production through actual death loss or lowered marketing weights or restricted grazing use. Each of these plants presents separate and distinct problems in control in which proper management is the key to reduced animal losses and retarding further invasions. If control and eradication are resorted to, it should be accompanied by reseeding to the most suitable species wherever the original forage cover has been markedly reduced.

Grazing in the forest range provinces in most instances can be fitted into other land uses provided livestock numbers are properly adjusted to the forage supply, range and livestock carefully managed, and range improvement practices such as reseeding and noxious plant control adopted wherever necessary. General adoption of such range improvement practices is necessary to the realization of a sound land use program wherein all land values including range, timber, wildlife, recreation, and most important of all watersheds play an important part. However, such multiple land use must be coordinated and integrated to the extent that in many instances one or more uses play a minor role or, if necessary, are even excluded insofar as local or regional demands may require.

A summary of the major factors and characteristics pertaining to the six range areas or provinces in the Southwest is presented in Table 4. It will be noted that the urgency for future range research is characterized as "high" in four of the six range areas--namely: ponderosa pine-bunchgrass, woodland, semidesert grassland and shortgrass. This appraisal is based mainly on the importance of the livestock industry, other land values, present range condition and local population pressure.

Table 4.--Summary of the factors and characteristics pertaining to range areas in the Southwest.

	RANGE AREAS					
	Ponderosa Pine	Pinyon-juniper: chaparral-oak blue grama, galleta	Semidesert grass Creosote mesquite	Shortgrass blue grama, buffalograss	Sagebrush, blackgrush, rabbitbrush	Desert shrub creosotebush saltbush
Area (acres)	18,197,657	33,364,311	59,970,557	80,079,468	17,399,167	23,780,103
Pct. regional area	7.8	14.3	25.8	34.4	7.5	10.2
Avergge elevation	7,500	5,000	4,000	3,500	4,000	1,500
Annual precipitation inches	22	15	12	17	10	6
Drought frequency 1/	0 to 2	1 to 2	2 to 3	1 to 3	2 to 3	2 to 4
Watershed value	Extremely high	Intermediate	Low	Intermediate	Low	Low
Silt contributing	Low	High	High	Moderate	High	Low
Wind erosion	Low	Moderate	High	High extreme	High	High
Value for timber	Extremely high	Nil ?	Nil	Nil	Little to none	Nil
Wildlife-recreation value	Extremely high	High	Low	Low	Low	Low
No. of cattle	142,048	279,495	1,093,795	1,803,981	41,405	284,644
Pct. of region	3.9	7.7	30.3	50.0	1.2	6.9
No. of sheep	413,854	659,634	571,072	4,559,366	374,611	67,384
Pct. of region	6.2	9.9	8.6	68.6	5.6	1.0
Local population pressure on resource	High	High	Low	High	Low to intense	Low
Past range research	Fort Valley	Meager	Jornada, Santa Rita	BPI & SCS Rocky Mt F & R	Meager	Some at Santa Rita
Present range research	Fort Valley Work Center	Fort Vally Work Center	Jornada Wk Ctr N.Mex.A & M Tucson Wk Ctr (Santa Rita)	BPI & SCS Rocky Mt F&R Exp. Sta.	Indian Serv. Int.F&R.E.S. (desert range)	Some at Santa Rita
Urgency of future range research	High	High	High	High	Low	Low

1/ Frequency of drought years with 10-year period (drought year based on 75 percent or less of average yearly rainfall).

The research needs for technically trained men to implement the needed research in grazing management is presented in Table 5. The requirements for the other two range provinces--desert shrub and northern desert shrub are not listed because of the low priority and the character of range research (largely work of an exploratory nature) needed is mainly in reseeding, noxious plant, control, or wildlife management.

The total technical requirements are 16 man years per year. This would require an annual appropriation of about $112,000. This is estimated on the basis of $7,000 per man, which would provide for seasonal field assistants, labor (including range riders if necessary), stenographic and statistical help, part of the overhead of work center leaders, part of the salary of Range Division Chief, equipment, and transportation.

Table 5.--Technical requirements for initiating and carrying out range research in grazing management in four range provinces.

Range Area	Range Research Phase	Professional Grade				
		P1	P2	P3	P4	P5
Forest Range including both Ponderosa Pine-bunchgrass and woodland range provinces.	Range condition criteria			1		
	Demonstration allotments			1		
	Effect of reproduction			1		
	Utilization			1		
	Range Study Plots			1		
Short grass	*Range condition criteria	1	2		1	
	Management and handling livestock					
Semidesert grass	Santa Rita (Management mixed grama)	1	2	1		
	Jornada (Management black grama-tobosa)	1	1	1		

* To be decided following problem analysis.

RECOMMENDED PROGRAM ON BASIS OF PRESENT FUNDS

At the present time (fiscal year 1948) funds are provided for four men in grazing management research. This includes the services of Culley (P-3) and Canfield (P-2) at the Santa Rita work center, Ares (CAF-7) at the Jornada work center, and Arnold (P-3) at the Fort Valley work center. To recommend a program of research other than that now under way is difficult because of the present work load of each of the individuals concerned, plus ear marking limitations imposed by work center appropriations. However, in spite of this, there is real need for reconsideration of the entire program of work in grazing management research. The Fort Valley, or northern Arizona, research needs and priorities are now being set up--and ultimate plans will be made in consultation with National Forest Administration. Although the west Texas and northern New Mexico work centers have not as yet been provided for financially, there is real need for the Station to critically consider the problems within both these areas. Some range work (reseeding) is now underway in northern New Mexico. A problem analysis should be made in the immediate future for the shortgrass range province in western Texas by the Range Division Chief. This analysis should include all phases of range research--management, reseeding, noxious plant control.

At the Santa Rita the study phase to compare the effects of rotation--deferred grazing and mesquite removal with yearlong grazing, both with and without mesquite removal, should be undertaken. This would require additional help on the ground (part of this might come from the new Research and Marketing Act funds and another possibility is the transfer of Canfield from Tucson to the Santa Rita). It would probably require further the streamling of field work such as on the utilization and forage crop surveys on the remainder of the Santa Rita and financial assistance from the new Research and Marketing Act funds for mesquite elimination and some seasonal field assistance. The remainder of the Santa Rita would be operated on pretty much the present basis but with some tightening up on livestock weight records.

On the Jornada it would be possible to undertake the rate of stocking study, provided the New Mexico College of Agriculture and Mechanic Arts is willing to cooperate and funds can be found for a P-1 grade technician. It would also require streamlining of work on the remainder of the area—particularly the annual quadrat charting (which could be placed on a periodic basis). The remainder of the Jornada would be operated on somewhat the present basis but would require closer cooperation from the cooperator in such matters as securing comparative weight data on supplemental feeding, production from different range types, and various livestock handling phases.

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